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## EDITORIAL

### THE METALS OF TOMORROW

The human mind has many remarkable attributes, but one of the most outstanding is man's ability to perceive concepts above and beyond the realm of his own experience. In the field of science we are constantly using terms which represent calculations beyond observed data and which have no real meaning in the physical world as it is now known.

An example of this occurs when we use the term Absolute Zero, knowing full well that this is a state to be approached but never attained. The same is true when we realize that in the entire physical world there is nothing which can qualify as being a "pure" substance, yet this does not prevent man from conceiving of such a material nor prevent him from trying to attain it.

Fortunately, man as the idealist and theorist usually triumphs in a scientific controversy over man as the practical realist. Nowhere, perhaps, is this victory more apparent than in the field of metallurgy. Here, in the last few years, drastic changes have occurred in the conception of the misused term "pure metal."

All of the so-called "wonder metals" of today—titanium, zirconium and lithium belong in this select group—exist now in practical forms and provide properties once considered unattainable mainly because metallurgists, scientists and engineers have all been willing to reevaluate the meaning of the word "pure."

In order to provide our readers with the story of technical developments in the heat treatment of one of these metals, we have published in this issue the results of the research of Mr. Paul D. Frost of Battelle Memorial Institute in the field of the heat treatment of titanium. (See page 6).

From time to time as new horizons are unfolded and new developments occur, we shall keep our readers informed, believing as we do with the historian who said, "often do the spirits of great events stride on before the events, and in today already walks tomorrow."

*Herbert R. Herington*

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# HOW TO SELECT THE PROPER HEAT TREATING EQUIPMENT

*By* **Carl F. Burling,** *Sales Manager*
*Industrial Furnace Division*
*Lindberg Engineering Company*
*Chicago, Illinois*

JUST a few years ago, it was common practice in industry to tool up for production of a new assembly by the specification and purchase of all the metal cutting and forming equipment without thought for heat treatment. The machines were necessary to shape the part, but the heat treatment was incidental—a somewhat necessary evil—to be performed in ancient equipment by one who knew through experience just what motions to make. That the old time heat treater was so successful in most cases was through his own untiring efforts and no thanks to those who could have provided better equipment.

Today there is an awareness of the importance of heat treatment. Both the designer and manager know that the ultimate properties of a given part can be attained only by the proper selection of steel followed by the correct heat treating. More and more is the selection of furnaces and auxiliary equipment becoming a first-line decision along with the metal forming tools. This is, of course, as it should be. Metal treating is now a science. We know what is happening to the physical structure of steel as we heat and cool it. We know, too, the need for more accurate control of temperature and the prevention of oxidation and decarburization because of their profound effect on the finished part.

So, today, plans are made at once for suitable heat treating means. More time is spent in planning due to the realization of the countless manhours of production and quantities of material that can be lost by poor heat treatment. To protect the investment in time and material, and to bring out the best in the product, we must select the furnace and auxiliary equipment after careful consideration of all the factors.

Several salient facts must be set down before proceeding, and these will help to provide the boundaries for the selection.

1. What materials are to be handled?
2. What are the general shapes and sizes of the parts and the quantity of each?
3. What specific heat treatments are involved?
4. What proportion of the total work fits into each treatment?

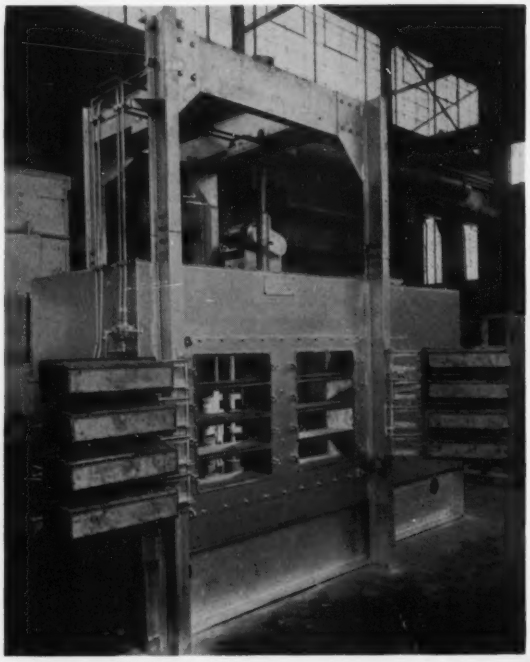


**Fig. 1—A specialized cyclone tempering furnace with built-in hydraulic press to temper straighten circular saws.**

5. Is there any special handling requirement due to the physical shape of the parts or to the production sequence?
6. Where is the equipment to be located?
7. What heating media are available?
8. Can it be an automatic operation?

### *The Number of Furnaces Required*

The first real consideration after making the above data available is the determination of the number of furnaces required for the variety of parts and treatments scheduled. The number of furnaces actually relates more nearly to the treatment required. Furnaces of the forced convection type are essential for any operations in the temperature range from 300° to

1400°F. Forced convection is useful for many operations from 1400° to 1800°F in which small forgings, for instance, are handled in rather densely loaded baskets. It is also advantageous for the circulation of atmosphere in this operating range to insure that all sections of the load are uniformly in contact with the protective or case-forming gases. Furnaces heating by direct radiation are often used in the range from 1200° to 2000°F and from 1800° to 2500°F such units are essential. Thus, if the various operations entail more than one of the temperature ranges indicated, it is essential that a suitable furnace be provided for each.

This is not to say that one furnace is not capable of operating in all temperature ranges, but it operates efficiently and accurately, only in its own range. A radiation type furnace can, in a pinch, be used for tempering at 600°F, but the load would have to be light and evenly spread out. Because of the high heat input required to attain the temperatures for which it was built, the control temperature would fluctuate widely. Since radiated heat travels in straight lines, parts of the load would be shielded from other sections and would not be uniformly heated. In this range also, black body radiation produces slow and uneven heating. As a result, the substitute would produce less work with a wide hardness variation which is hardly a recommendation.

If part of the work is high speed steel or stainless steels requiring temperatures over 2000°F, it is important to consider a separate furnace for this range. In the first place, the construction requirement is considerably different to provide against excessive radiation loss and high maintenance and secondly, much of this work requires preheating which prevents too rapid heating, particularly on intricate parts, and this entails a second unit.

So the number of furnaces required is determined by the temperature ranges to be covered. The number of units is also prompted by a desire for flexibility. Two small units may be selected in place of a large one because of large fluctuations in production. One of the two small furnaces could be shut down completely when not in demand, whereas the large unit would operate at partial capacity. The selection of the two units would be a hedge against complete shut down for repairs. In an emergency, at least half capacity would be provided.

On the opposite side of the ledger would be the increased cost of two units instead of one, due in large part to duplication of controls. A further disadvantage would be the added floor space required for the dual installation. Thus, the advantage of production flexibility would have to be weighed against the added first cost and the space requirement.

### *Continuous or Batch Equipment?*

A major consideration in the selection of furnaces has always been the respective advantages of continuous or batch equipment. Only your own particular conditions can answer this problem. The general shapes, sizes and quantities of the parts as previously mentioned will help to provide this decision as will the need for special handling or the producton sequence. The commercial heat treating shop which has a variety of production work in quantity can certainly justify continuous hardening and quenching equipment. This may be the cast link belt conveyor type of furnace with vertical discharge into the oil tank and removal by some form of flight conveyor. Such a furnace is applicable to bolts, nuts, springs, wrenches, stampings, fasteners, and the like. It may also be an intermittent pusher furnace in which heavier parts are pushed by hydraulic cylinder or mechanical rack and pinion through the furnace on cast alloy trays. The loaded trays may be automatically quenched on elevators built into the quench tank or the parts quenched individually. Parts such as gears may be manually placed between dies for quenching to prevent distortion. Crank shafts may be manually quenched because position during immersion is important to maintain straightness. Parts which are not subject to distortion but would be damaged by falling into the quench against each other can be elevator-quenched on the carrier tray.

**Fig. 2—An application of continuous cast link belt conveyor hardening furnace with vertical cyclone batch tempering furnaces for heat treating stampings. The hardening furnace is electrically heated and provided with protective atmosphere. The tempering units are gas fired.**

The tempering equipment may be continuous also, but probably such equipment is of more value to the production plant where a given furnace line handles a high production of very few types of work. The furnace would be of the convection type in either case and designed to match the hardening equipment. A mesh belt conveyor tempering furnace should follow a cast link belt conveyor hardening furnace since the parts are random loaded without need for containers. The pusher hardening furnace would be followed by a pusher tempering furnace or one of the chain conveyor type which woud carry the individually loaded trays. In either case, it is most important that the tempering equipment be properly sized for the production. Normally, the tempering furnace would be considerably larger than the hardening furnace for the same production. This is because at least an

hour at temperature is usually specified for tempering and it takes longer to heat through a given part at the lower temperature involved in tempering.

Batch-type tempering equipment is often used with continuous hardening furnaces, and it is particularly advantageous in a commercial heat treating plant. Vertical furnaces are used and the work is handled in baskets. The baskets are placed to collect the work discharged from the quench and when full, are washed or allowed to drain and then placed in the tempering furnace. Several such units are used in place of a continuous furnace and have the advantage of allowing variations in tempering temperature from one lot to the next if desired. They generally save space because the work is piled up instead of spread out on a belt or tray. They are more economical to operate because they operate with fully closed doors and are smaller in overall size. They require no more manpower since an attendant usually is present with continuous equipment, and the batch type requires an attendant for only a few minutes' loading and unloading time every hour or two, depending on the cycle. Initial

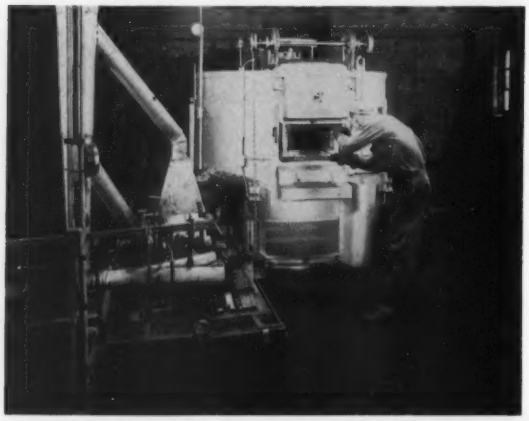


**Fig. 3—A rotary hearth furnace being used to handle trowels which require individual quench in a fixture.**

cost is much less for the batch units, and the use of more than one again provides insurance against complete shutdown. The batch type tempering furnaces also lend themselves to the handling of miscellaneous large pieces such as large shafts and gears which could not be handled in continuous equipment except in units made specifically for those products.

The use of continuous tempering equipment may be justified where high production of similar parts over long runs is in prospect. Such conveyor equipment may be desirable also when a continuous flow of material from a previous operation is to be fed on the same basis to succeeding processes. Such an operation might be the production of steel cartridge cases which come to the equipment in a continuous flow and pass on to the succeeding finishing operations in the same manner. The continuous tempering furnaces are available as mesh belt units for handling bulk parts such as screws, bolts, stampings and the like. They are available as pusher furnaces or chain conveyors to match up with the hardening furnace as indicated previously, and these units would handle large forgings, gear blanks, shafts, leaf springs and large bearing races. Small parts would be handled only in baskets. Specialized conveyor equipment is available with carriers designed to handle assemblies to keep the components separated and in a desired position. A convection type furnace for the 1000°F stress relief of output shafts was designed on this basis. The shafts were 15" long and had a 4½" diameter flange. A chain conveyor was used with slats across the chains in which were mounted sockets to accept the shaft flange. Thus, the shafts were carried vertically and could not bump each other and produce nicking.

For hardening, annealing, carbonitriding and carburizing, the major emphasis recently has been the use of automatic batch-type furnaces. These units are equipped with enclosed elevator quench tanks and are very compact. They are constructed with heat storing refractory linings to provide a fly wheel effect and speed the rate of heating. They are very flexible units and yet provide accurate control of temperature, time and quench. They are available for electric or gas heating and the vertical, straight-through radiant tubes on the gas-fired units save considerable space and result in smaller overall dimensions. Corrtherm elements in the electric furnace are space-saving too, as they are completely exposed in the work chamber and yet are designed for long life under high carbon potential atmospheres. For a most versatile furnace with high production features, the automatic batch-type furnace is suitable for a wide group of operations.

Briefly then, batch-type hardening and tempering furnaces are used where extreme flexibility is required. They are preferred for short-run jobs and particularly those where individual handling is required. As a compromise, the rotary hearth furnace fills a very important need as it is the most economical, initially and in operation, of all the continuous units. Yet, it lends itself nicely to individual handling. The reheating of gears requiring press quenching or the hardening of hand trowels followed by fixture quenching are naturals for the rotary unit. Floor space requirements are a minimum with the rotary hearth unit, and it does have a large measure of flexibility.

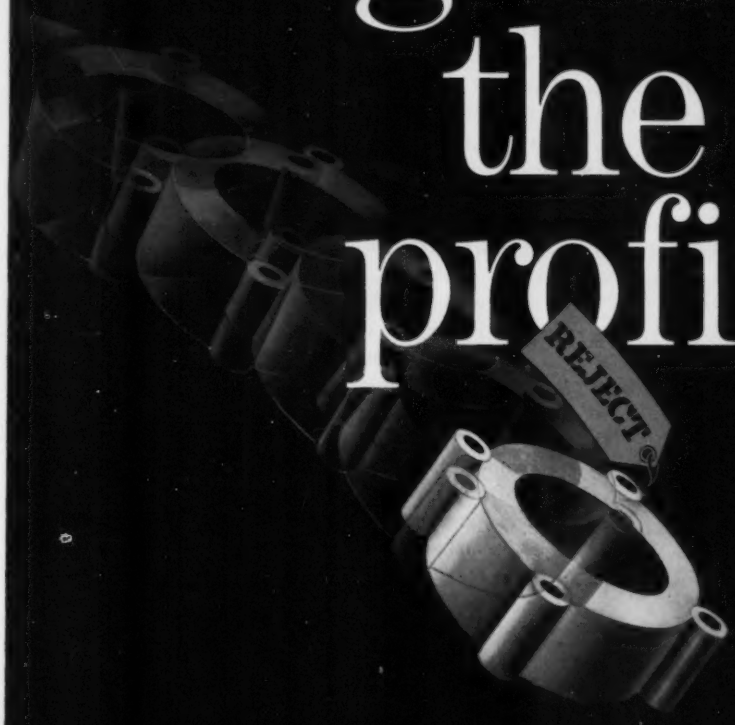
### *Specific Handling Problems Require Special Furnaces*

The matter of special handling has been mentioned and in most cases would probably dictate a special-purpose furnace, particularly if production is fairly high. If production is low, it will pay to investigate the possibility of minor modifications to standard units so the application is not so limited.

A small furnace has been made with a single chain conveyor on which are attached cups to hold in a

*(Continued on page 21)*

# there goes the profit...

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# HEAT TREATMENT OF TITANIUM

*By* **P. D. Frost,** *Chief,*
*Light Metals Division*
*Battelle Memorial Institute*

THE use of titanium for defense purposes is focusing the attention of more and more small manufacturing companies on this metal. Commercial heat treating companies undoubtedly have been giving serious thought to questions such as, "Should we start now to learn something about titanium? Will titanium be heat treated extensively in the future and, if so, can we develop a commercial titanium heat treating business?" An affirmative answer to these questions seems justified. The most important objective of the article is to acquaint the readers with the technical aspects and the problems involved in titanium heat treatment.

It is appropriate to begin by referring to the growth of titanium production. Titanium sponge production for the last several years is shown in Fig. 1. Along

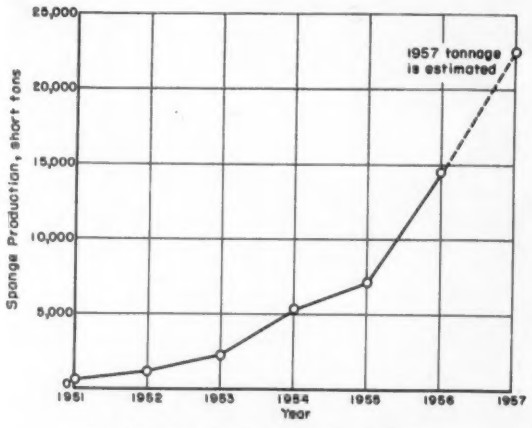



Fig. 1—Growth of titanium sponge production.

with this growth has come a reduction in the cost of the sponge and of mill products. These trends offer encouragement to manufacturers to seek contracts for titanium products. In fact, the current shortage of titanium mill products has made more than one manufacturer of end items consider installing their own melting facilities. But what about the heat treating business?

Having reasonable assurance that titanium is here to stay, we should look next at the kinds of titanium products that will require heat treatment and the types of heat treatment they will need. For the next several years, it is expected that airframe components, including sheet, fasteners, extrusions, and forgings will consume the bulk of titanium produced. Eventually, plate and castings will find their way into ordnance items, such as armor, into the shipbuilding industry, and into the chemical industry. However, aircraft needs may overshadow these markets for titanium for a number of years. The important point is that in order for titanium to remain competitive with other structural materials in aircraft, titanium alloys will have to be heat treated to relatively higher strength than has been adequate in the past. As titanium production increases and as more metal is used in the heat treated condition, it is logical to assume that commercial heat treating companies will acquire a share in this activity.

In the development of any new metal or alloy, heat treating technology and practice invariably lag behind manufacturing technology. This was true of titanium. It has only been during the last two or three years that manufacturing technical people have learned how to apply heat to titanium alloys without in some way damaging their properties. For example, the duplex quench and age heat treatment process is just beginning to be used successfully to increase the strength of titanium alloys, even in the plants of aircraft companies and titanium producers who have had the most experience in titanium technology. It must be expected that before aircraft companies and other prime defense contractors can become important sources of titanium business for commercial heat treaters, these companies will first have to be satisfied that their own heat treating procedures are adequate. In the meantime, the commercial heat treating companies will have to learn these procedures and to understand their effects on the properties and quality of the heat treated parts.

The subject of heat treatment is too vast to cover completely in this article. However, the essential information, a knowledge of which will permit successful heat treating practice, is included. Four topics will be considered:

1. Obtaining improved properties through solution and aging heat treatments.
2. Avoiding embrittlement by the omega phase after heating.
3. Avoiding loss of ductility as a result of overheating.
4. Preventing contamination and distortion during heat treatment.

### *Obtaining Improved Properties Through Solution and Aging Heat Treatments*

As a result of the research which led to an understanding of the embrittling omega phase, heat treating procedures now exist which are capable of producing many combinations of strength and ductility in titanium alloys. Fig. 2 presents examples of properties obtained after the earliest research on the omega phase. Since this work was done, many others have applied similar heat treatments to various commercial alloys and outstanding properties have resulted.

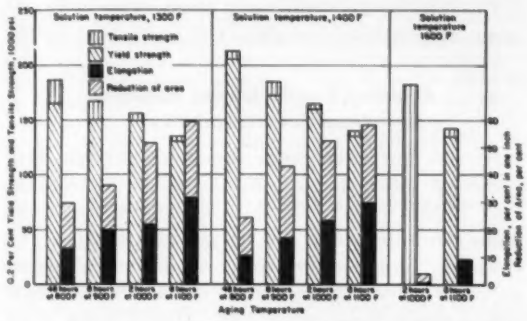



Fig. 2—Tensile properties of a Ti-3Mn-1Cr-1Fe-1Mo-1V alloy rolled at 1450°F. to ½-inch-round bars and solution treated and aged as shown.

In order to understand and overcome the problems associated with titanium heat treatment, it is essential to have a little knowledge of the metallurgy involved. This can be made relatively easy by use of schematic diagrams like those shown in Fig. 3. The elements iron, chromium, manganese, molybdenum, vanadium, aluminum, and tin are the principal alloying agents in commercial titanium alloys. The first five of these are called beta-stabilizers because they dissolve almost entirely in the high temperature beta phase, strengthening it and causing it to be retained after heat treatment. Beta can be made to transform into alpha and other phases at intermediate temperatures, and this characteristic makes titanium alloys heat treatable.

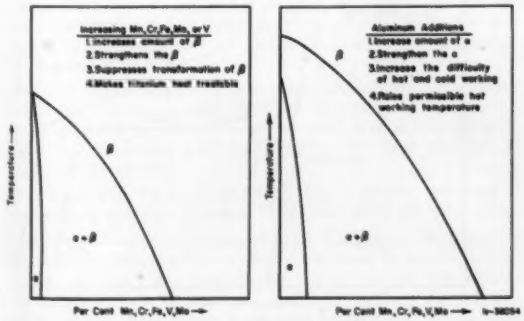



Fig. 3—Binary Ti-X phase diagram and section through ternary Ti-X-Al phase diagram showing functions of the beta stabilizing elements and the effect of an aluminum addition on these functions.

Aluminum and tin dissolve almost exclusively in the low temperature alpha phase, strengthening it and increasing the temperature at which alpha titanium transforms completely to beta. As will be shown later, titanium alloys should not be heated or hot worked any more than necessary in the all-beta temperature range. Obviously, aluminum is a desirable addition in that it raises the permissible heating temperature, as Fig. 3 shows. Likewise, aluminum raises the elevated temperature strength of titanium alloys. On the other hand, this strengthening effect of aluminum at higher temperatures makes it necessary to forge, roll, and extrude alloys like Ti-6Al-4V at higher temperatures than alloys without aluminum.

The heat treatable alloys are strengthened by the duplex treatment. This consists of 1) a solution treatment to transform part of the alpha phase to beta and dissolve the manganese, iron, or other elements uniformly in the beta phase; 2) a quench, in air or water, to retain the sluggish beta phase from transforming back to alpha during cooling; and 3) an aging treatment, to effect controlled partial transformation of beta into fine, uniformly dispersed alpha. The fineness of the resulting alpha-beta microstructure determines the strength and ductility of the alloy, and this is controlled by the aging temperature and time.

The role of solution temperature in the heat treatment of titanium is explained in Fig. 4. A hypothetical alloy of composition A, when heated above the cross

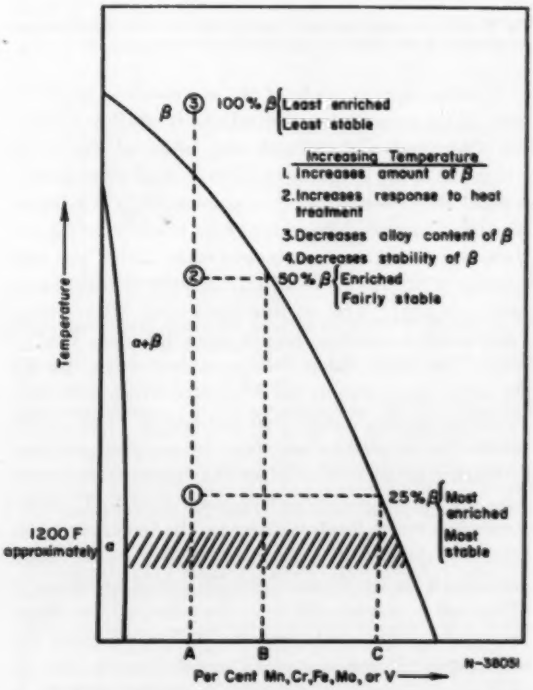



Fig. 4—Effect of annealing or solution temperature on the relative quantity, composition, and stability of the beta phase.

hatched area (about 1200°F), will start transforming to beta. At temperature (1) it may contain roughly 25 per cent beta having the composition indicated by C. This beta, being relatively rich in alloy content, is comparatively stable and will not transform readily if the alloy is cooled. If the alloy is heated to temperature (2), it becomes approximately 50 per cent beta of composition B. In this condition the alloy is potentially capable of extensive hardening by virtue of the amount of beta available to transform in subsequent quenching and aging steps. The relative effectiveness of utilizing a higher solution temperature to create higher strength is evident from the tensile properties shown in Fig. 2. The beta at temperature (2) is relatively lean in alloy content, and, hence, would be unstable if retained during cooling. If the alloy is heated above the transus to temperature (3), it transforms completely to beta of composition A. This beta is the least enriched and, hence, the least stable of the three conditions described.

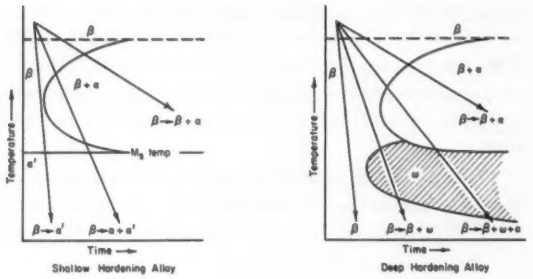



**Fig. 5—Effect of fast and slow cooling rates on beta transformation mechanisms in two different types of titanium alloys.**

A comparison is made of the mechanisms by which beta phase transforms in a relatively shallow-hardening alloy and a deep-hardening alloy in Fig. 5, in which the TTT diagram familiar to steel heat treaters is used. Here, to simplify the explanation, it is assumed that the alloys are 100 per cent beta before cooling, i.e., they are cooled from a temperature above the beta transus (a practice to be strictly avoided in commercial heat treating). The shallow-hardening alloy cannot be quenched rapidly enough from the beta field to retain the beta phase. During a fast water quench the alloy transforms at the Ms temperature from beta to alpha prime, a distorted hexagonal phase whose needle-like microstructure has the same appearance as martensite in steel. Unlike that in steel, the titanium martensite has relatively low strength. If cooled somewhat more slowly, as in air, the beta will transform to a mixture of alpha prime and alpha. If cooled very slowly in the furnace, the alloy will transform to alpha and beta, and will be in the annealed condition. In certain alloys, including the Ti-6A1-4V alloy, the martensite formed during a rapid quench can be aged or tempered to produce strengths as high as 190,000 psi. However, as the TTT diagram shows, the quench must be rapid and the section must be relatively thin (i.e., not over about ½ inch) or the softer products will result.

The deep-hardening alloy, on the other hand, retains beta phase during a rapid quench (the nose of the TTT curve is well removed from the zero-time axis). This retained beta, when subsequently aged, will transform during controlled aging to give the extremely high strengths described earlier. If this alloy is cooled very slowly in the furnace, it, too, will transform to a soft alpha-beta structure. If, however, the alloy is cooled at certain intermediate rates, the omega ($\omega$) phase will form from the beta. Omega is a transition phase which can cause severe embrittlement. More will be said about this in the next section.

### *Avoiding Embrittlement Resulting from Beta Instability*

As has just been seen, the more strongly beta-stabilized alloys like Ti-2Cr-2Fe-2Mo, Ti-4A1-4Mn, and Ti-3Mn-1Cr-1Fe-1Mo-1V, may form the omega phase during an air cool by the reaction $\beta \rightarrow \beta + \omega$. It is extremely important, therefore, that when alloys are annealed at temperatures above about 1200°F, they be cooled slowly through the 1300°-1100°F range in order to permit the formation of alpha ($\beta \rightarrow \alpha$) instead of omega.

Two methods for avoiding the formation of omega during the cooling period following either an anneal or a hot working operation are shown schematically in Fig. 6. Furnace cooling through the temperature range in which beta transforms causes rejection of a great deal of alpha and consequent enrichment and stabilization of the remaining beta by the alloying element. Similar stabilization is effected by holding or reheating the alloy for 4 to 12 hours in the lower transformation temperature range, i.e., about 1100°F. Parts which have not received a stabilization treatment of this type will retain the beta phase in an unenriched,

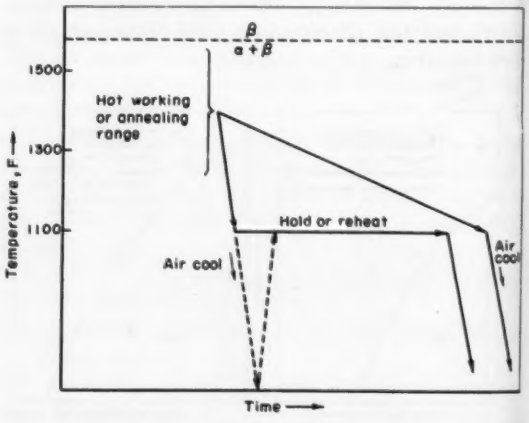



**Fig. 6—Two methods for stabilizing beta phase after hot working or annealing titanium alloys.**

*(Continued on page 31)*

# HEAT TREATING HELP

THE CARPENTER STEEL COMPANY, 198 W. Bern St., Reading, Pa. No. 4 in a series

## QUENCHING PROCEDURES

Quenching is one of the most important—and least understood steps in the heat treating operation. Anyone who has ever seen a piece of hot tool steel disappear into a quenching tank, and come out cold a few seconds later, can appreciate how difficult an operation it is to study. However, when he further considers that it is at this stage that the steel hardens—and further, that warpage, size change, cracking, internal strains, and soft spots are all products of this operation, he gains some idea of its importance.

Quenching may be conducted in various media, or coolants, the most important of which are water, oil and air. Selection of the medium depends upon the analysis and hardenability of the steel. The water may be fresh or it may contain some salt or caustic soda, usually the former.

**Water Quenching**—A still bath of fresh water is *not* an ideal quenching medium for tool steel. Fresh water has a tendency to form considerable steam on the surface of the hot metal in the first stage of the quench, and this together with any dissolved gas released from the water, tends to form an insulating film on the surface of the work, especially in holes and recesses that are congenial to gas pockets. The hardener can actually *see* this happen in a tank of clear fresh water; red hot spots will persist after most of the tool has become black. Contrary to general opinion, water-hardening steels are *more* likely to crack when quenched in fresh water than they are when quenched in salt brine. They are also more likely to contain soft spots. Fresh water is entirely satisfactory in a flushing fixture, because gas bubbles cannot adhere to the steel.

When common rock salt is dissolved in fresh water it not only inhibits the formation of steam at the metal surface, but also lessens the tendency of the bath to absorb and release atmospheric gases. This allows direct contact of the bath and hot metal surface, and consequently more uniform cooling in the important first stage of the quench. This is the sole and only reason for adding the salt. Many people think that salt brine will quench a tool faster than fresh water. This is not true. The brine "takes hold" and "wets" the tool all over immediately and cools it uniformly. For this reason, the quenching job is likely to be completed faster in brine than in fresh water. Fresh water "takes hold" only in spots where no steam or gas has been deposited—but in these spots it actually cools faster than the brine. This non-uniform quenching—ranging from extreme rapidity down to practically no quench at all—is the thing which sets up tremendous strains in a tool and may cause it to crack.

For still water quenching tanks, use a solution of 5% to 10% rock salt (ice cream salt) dissolved in water. This is made by adding about ¾ pound of salt per gallon of solution. Tested with a salinometer (salt hydrometer) the bath should read between 20 and 40.

For best and most uniform results, it is well to keep the quenching solution between 60°F and 90°F the year round.

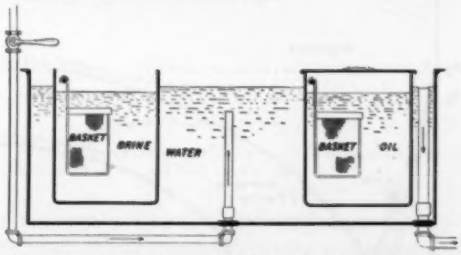
All water-hardening steels of the Carpenter Matched Set should be quenched "naturally"—and may be quenched right down to the bath temperature. These steels are easy to harden—heat them right up, soak a little, then quench them right down. This saves time and trouble—it is the safest procedure—and it makes better tools.

**Oil Quenching**—Use a good grade of commercial quenching oil, preferably maintained between about 100°F and 130°F. Warm oil will quench better than cold, sluggish oil.

High Speed Steel should be removed from the quenching bath as soon as it can be handled comfortably with bare hands and then drawn promptly. High Speed Steel should *never* become cold before drawing because cracking can result from the high internal stress developed by quenching. Other oil-hardening Matched Tool and Die Steels should be quenched right down to bath temperature, and may be allowed to remain in a basket in the oil for the few minutes while they are waiting to be drawn.

A convenient layout for quenching is illustrated below. The large tank is filled with fresh water which serves to cool both the brine and the oil. Water is admitted through a vertical standpipe—sometimes called a "bubbler". With this water flowing, certain types of tools can be quenched in the upstream of the bubbler with little danger of gas pockets. It is important to note the nipple at the bottom of the bubbler pipe. This is to permit the connection of flushing equipment.

The water overflows through a standpipe at the right. Provision must be made to hold the water level at any point desired, because many types of flushing apparatus do not operate beneath the surface of the water—they must be out in the air. The water level is controlled by using overflow pipes of different lengths. The oil quenching bath should be provided with a cover to extinguish fires which can always occur in a busy hardening room. Do *not* allow water to leak into the oil tank. The water will accumulate at the bottom and inevitably cause cracked tools.




The baskets are useful for holding hardened tools during the short interval before they are drawn. Below the surface of the liquid they are protected from sudden temperature changes that might strike them in the air.

**Air Quenching**—For still air quenching, the best practice is to place the heated tool on a screen so that the air can circulate freely past it. Accelerated air cooling can be induced by using a common electric fan. This has the advantage of supplying a draft of *dry* air—but, unless specially arranged, the blast will cool one side of the tool faster than the others. Compressed air is also used—especially to concentrate the cooling at some point on the tool. Extreme care must be used to insure the blast being dry. Much water frequently accumulates in a compressed air line and this is likely to crack an air-hardening steel.

*In this issue of "Heat Treating Helps" we have discussed "Quenching Procedures". In a future issue of this magazine we plan to continue the discussion, outlining data on "Torsion Impact Test as a Guide to Better Heat Treating Results".*

# HOT OIL QUENCHING

*By* **L. W. Kalinowski,** *Staff Engineer*
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*Chicago, Illinois*

THE hot oil quenching process and the advantages derived from the use of oil as the quenching medium are described in this article.

### Hot Oil Quenching Process

Hot oil quenching is the process of quenching steel from its austenitic temperature range into an oil which is maintained between 200°F. and 450°F. Steel is held in the oil until the temperature of the steel, throughout, is equal to the bath temperature. Once temperature equalization is completed, the steel is removed and allowed to air-cool. The main purpose of this elevated temperature quench is to reduce non-uniform changes, warpage, and, in the case of high hardenability materials, to reduce the cracking potential. The process is not a complete panacea in that the heat treater is limited by increased material and fabrication costs of equipment or section limitations of quenched material. However, in the area of high strength steels used in aircraft or automotive industries (45-55 Rockwell "C"), with no finish grinding permissible, the process is a must. The treater is assured of an improved residual stress pattern and greater useful strength per given area.

Fig. 1 shows the relationship of hot oil quenching curves to a simplified transformation diagram (T-T-T curves). As will be shown, hot oil quenching can be accomplished either by full marquenching or modified marquenching. Both methods accomplish the transformation of steel from an austenitic to a martensitic structure. This occurs in the $M_s$-$M_f$ temperature range which varies with the steel. The steel must be quenched fast enough to avoid transformation of austenite to ferrite and carbide (in bainite or pearlite form) as shown in Fig. 1.

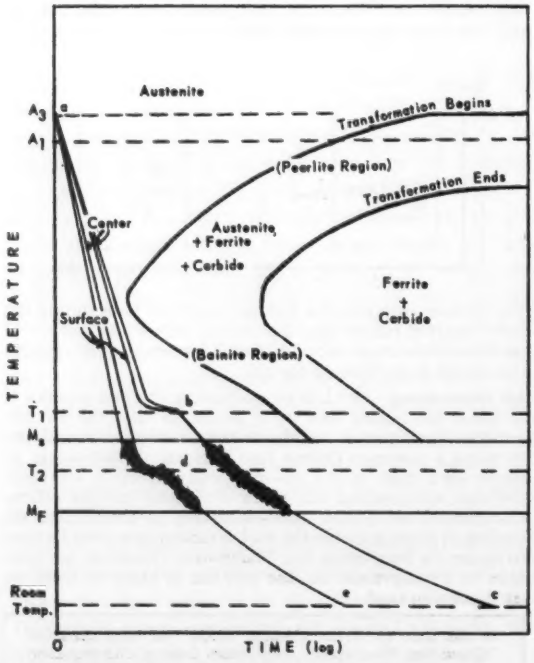


Fig. 1—Diagram showing the relationship of hot oil quenching curves to a simplified transformation diagram (T-T-T Curves).

### Full Marquenching

In full marquenching, as shown in Fig. 1, the temperature of the oil bath $T_1$ is above the $M_s$ (martensite start) temperature. $T_1$ is representative of a temperature between 300° and 450°F., and only a specialized marquenching oil can be employed in this temperature range. By following the curve a-b in Fig. 1, it can be seen that austenitic steel is cooled at a sufficiently rapid rate to avoid undesirable pearlite or bainite. The surface and center temperatures of the steel are then equalized at temperature $T_1$ before any transformation to martensite occurs. Subsequently, martensite transformation occurs slowly and uniformly without distortion or cracking when the steel is removed from the bath and allowed to air-cool to room temperature along b-c through shaded $M_s$-$M_f$ range. In conventional quenching, because temperatures from core to surface are not equalized through the martensitic range, transformation does not occur uniformly, thus resulting in a highly stressed and strained part. With full marquenching, distortion has been minimized and adequate hardness is achieved.

### Modified Marquenching

In many steels the critical cooling rate is such that faster quenching than provided by full marquenching is necessary to obtain full hardness. As shown in Fig. 1, modified marquenching, illustrated by curve a-e, occurs at lower oil temperatures (200°F. to 300°F.) to provide a faster cooling rate than full marquenching. In many steels this faster cooling rate is necessary to avoid intersection with the knee of the T-T-T curve which produces undesirable pearlite or bainite.

In modified marquenching, the steel is quenched along curve a-d to the oil temperature $T_2$. Since $T_2$ is within the martensitic range $M_s$-$M_f$ some trans-

formation to martensite occurs in the steel during its residence period in the oil. Small stresses due to this transformation do not cause distortion or cracking since they are readily relieved by the plasticity of yet untransformed austenite.

The steel is held in the oil until the center and surface temperatures are equalized. It is then removed from the oil and transformation is completed by air cooling along curve d-e. Although some transformation occurs before temperature equalization of steel is achieved at $T_2$, most of the hardening is accomplished in further cooling to room temperature. Consequently, most of the benefits of full marquenching are realized, and minimum distortion and elimination of cracking with high hardness results.

### *Points to Consider in Selection of Process*

In selecting a hot oil quenching process, either full marquenching or modified marquenching, the following points must be considered:

1. Critical cooling rate determined from the transformation diagram (T-T-T curve) of the steel.
2. Size and shape of workpiece.
3. Allowable dimensional changes.
4. Hardness and other physical properties.
5. Knowledge of the $M_s$ (martensite start) transformation temperature.

The following equation can be used to calculate $M_s$ for steels:

$M_s = 930\text{-}570C - 60\ Mn - 50\ Cr - 30\ Ni - 20\ Si - 20\ Mo - 20\ W$

A knowledge of the above five points is not only invaluable for selecting the correct hot oil quenching process but is useful also as a guide for selecting the proper oil. If the steel in question requires extremely rapid cooling with maximum hardness requirements, then a modified marquenching oil with accelerated quenching efficiency should be used. This oil can be employed in a temperature range of 200°F. to 300°F. If allowable dimensional changes of the workpiece are extremely small and the $M_s$ temperature of the steel is high, a full marquenching oil is required. This oil can be used between 300° to 450°F.

Fig. 2 shows continuous center cooling curves for stainless steel rounds quenched in three different oils. Oil A, which eventually has the fastest cooling rate, is generally employed for conventional quenching at 130°F. Oil B is a typical modified marquenching oil which exhibits intermediate cooling rate. It is used in the hot oil quenching process between 200°F. to 300°F. Oil C is a full marquenching product; and, as would be expected, shows the slowest cooling rate at 400°F.

### *Hot Oil Compared With Salts*

Increased application of the relatively new techniques which "interrupt" the conventional rapid

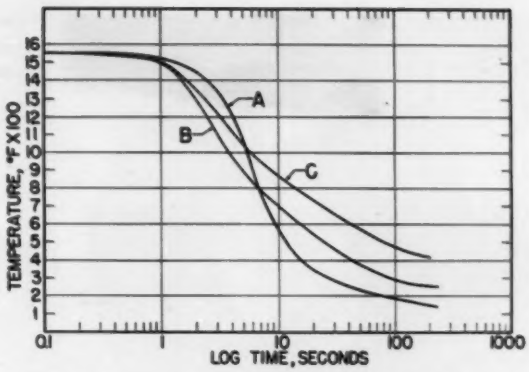


Fig. 2—Continuous center cooling curves for stainless steel rounds ½" diameter and 4" in length. Oil "A" is at 130°F., "B" at 250°F., and "C" at 400°F.

cooling from austenite temperatures by quenching in a "hot" medium has brought up the question of which medium is the most practical. To date the most commonly used are oils and salts. Although molten salt has a greater operating temperature range which includes all isothermal treatments from 325°F. to 1000°F., the distinct advantages for oil from room temperature to 450°F. are shown below.

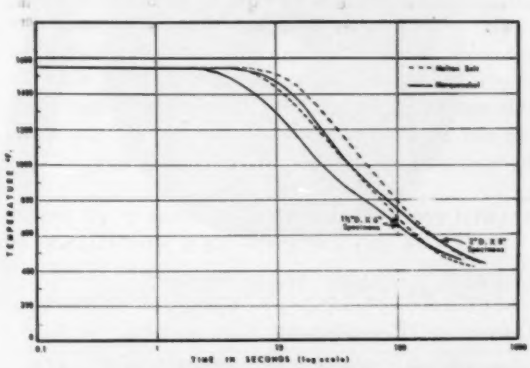

Fig. 3—Comparison of center cooling rates of 18-8 stainless steel bars with a marquenching oil and with molten salt.

Fig. 3 compares typical center cooling rates obtained on 18-8 stainless steel specimens with a marquenching oil and molten salt under identical experimental conditions. The marquenching oil curves at 400°F. show a higher cooling rate in the critical temperature range (around 1000°F.) than molten salt. This gives less of the undesirable structures before the bath temperatures are reached and assures higher and more uniform hardness.

Fig. 4 shows the appearance of SAE 1095 steel sheet specimens 6" x 3" x .016" (7 sheets per pile) after

Fig. 4—Appearance of SAE 1095 steel sheet specimens 6" x 3" x .016" (7 sheets per pile) after quenching with marquenching oil or with molten salt at 400° F.

Fig. 5—A ring-shaped SAE 4130 steel test specimen used for comparing dimensional changes due to quenching in 400°F. oil or molten salt. Ring dimensions are 1½" O.D. x 3/8" wall x 3/8" gap.

quenching with marquenching oil or molten salt at 400°F. It is apparent that the oil has produced less warpage in this particular test. At the same time, all specimens gave a Rockwell "C" hardness of 64-65.

Fig. 5 shows a ring-shaped SAE 4130 steel test specimen utilized for comparing dimensional changes due to quenching in 400°F. oil or molten salt. In this test the gap in the ring is measured before heating and after quenching. In quenching, the gap tends to open and the results are tabulated below:

MARQUENCHOL VS. MOLTEN SALT AT 400°F.
(DATA IS AVERAGE OF TEN SPECIMENS)

| Quenchant | Temperature | Average Change in Gap (inches) | Hardness Rc |
|---|---|---|---|
| Marquenchol | 400°F. | +.0035 | 38.4 |
| Molten Salt | 400°F. | +.0051 | 36.4 |

A summary of the advantages of hot oil over molten salt, within the temperature range mentioned above, includes the following points:

1. Oil can be used in lower temperature ranges that are not practical for salt.
2. Oil allows more economical installation, simpler heating arrangement; and the tubes used for heating can be used for cooling the oil.
3. Oil is easier to handle, especially at room temperature.
4. Oil is non-corrosive.
5. Many existing conventional oil quenching facilities are readily converted to a hot oil process.
6. Less drag-off with oil.

### *Heat Treating Equipment*

The furnace heating equipment must be of the best available, and the quench system correctly engineered into this overall heat treat unit. The quench and heating facilities should function as a single piece of integrated machinery for the best results. Fig. 6 illustrates an installation of modern heat treating equipment designed as an integrated unit to provide the superior qualities and characteristics obtainable through hot oil quenching techniques.

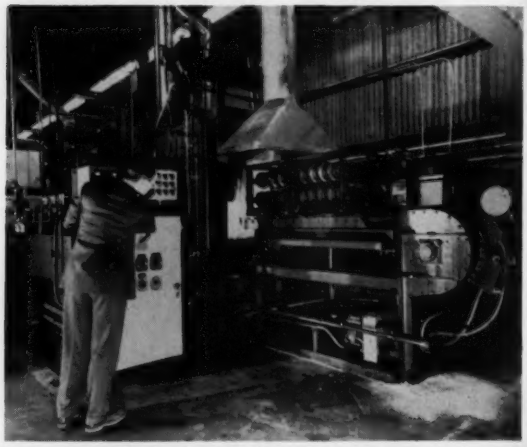

Fig. 6—An installation of a hot oil quenching furnace using the modified marquenching process at 300°F. on SAE 8620 and SAE 4620 carburized steel gears.

There are three critical factors that must be considered in heat treating and quench equipment for optimum results. They are *uniform temperature*, *controlled atmosphere*, and *adequate agitation*. The heat treating furnace must be designed for the uniform heating of steel to assure uniform transformation. The quench equipment must have a controlled or non-oxidizing atmosphere over the oil; otherwise oil at elevated temperatures in the presence of air would deteriorate very rapidly. In the presence of air, for every 18°F. over 140°F. the rate of oxidation of oil doubles.

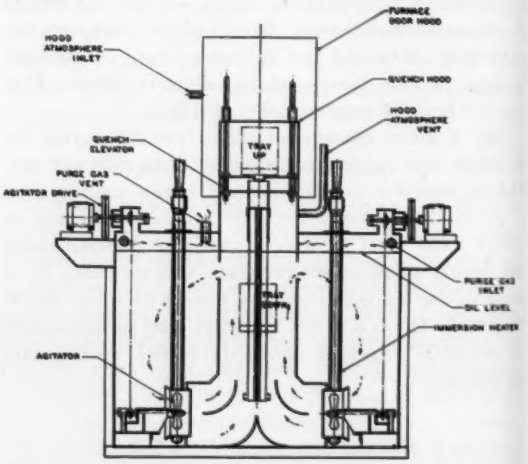


Fig. 7—Schematic diagram of a quench tank. Two impellar agitators at bottom control flow.

(*Continued on page 34*)

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# VACUUM MELTING AND ANNEALING

*By* **Roger Giler**

*Industrial Heating Department*
*Westinghouse Electric Corporation*
*Meadville, Pennsylvania*

THE use of vacuum in the metallurgical industry is a relatively recent development. The first commercial installation dates only back to 1938, when this process was first used in Germany for the annealing of plain carbon steel. In this country, vacuum processing appeared only a few years ago, with the widespread demand for the reactive metals such as titanium, zirconium and uranium.

Why use vacuum in metal treating? The effect obtained from operation under vacuum is twofold. First, vacuum is used as a protection in metallurgical applications which means that a protective gas is not required. Since neither air nor other gases are present in a vacuum, there is no danger of contaminating the charge. The second consideration is the fact that the vacuum is actually improving the product being treated. The basic improvement is the removal of included gases, and possibly even the decomposition of some oxides in the case of melting, which might have a tendency to weaken the metal. Such degassing can be conducted either in the molten or solid state.

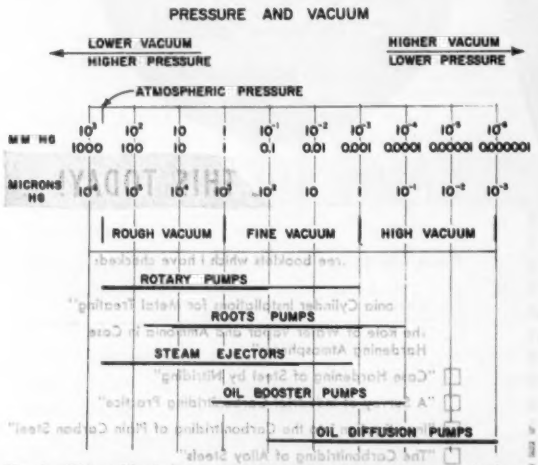



**Fig. 1—This table indicates what is meant by a vacuum and shows the common units employed in expressing vacuum.**

## Vacuum Equipment

Quite frequently it is difficult to obtain information on the equipment used for producing a vacuum. Hence a review of vacuum equipment should be helpful here. Fig. 1 indicates essentially what is meant by a vacuum and indicates the units employed in vacuum. Note, that the table shows the range covered by various types of pumps and it is immediately apparent that one single pump cannot cover the whole range.

The mechanical pump is the oldest and most common pump. It is essentially nothing more than a compressor operating against atmospheric pressure.

Another type of mechanical pump is the so-called Roots pump or mechanical booster pump which has a higher *speed* than the mechanical pump but unfortunately cannot operate at the higher fore *pressures*.

Another method for producing a vacuum and which has not been considered too seriously to date, is the steam ejector. A steam ejector system for high vacuum would be built up of at least six (6) of these units in series. It is interesting to note that the speed of the steam through the nozzle of a steam ejector pump is close to 35 times the speed of sound.

**Fig. 2—Shown here is an oil diffusion pump with the "umbrella" unit on the left. (*Photo courtesy of Consolidated Electrodynamics Corp.*)**

The most widespread pump used for high vacuum is the mercury or oil diffusion pump (Fig. 2). The diffusion pump will operate only with a fore pressure of 1/1000 of an atmosphere or less. Therefore, it has to be used in series with a mechanical type pump. This pump is very intriguing mainly because it has no moving parts. The pumping speed of such a pump compares favorably with the highest speed of the largest mechanical pump made to date.

Another type of pump is the combination diffusion ejector pump which applies the principles of the steam ejector, using oil vapor in place of the steam, and backing up a diffusion stage.

## Vacuum Measurement

The measurement of high vacuums is a complex

subject in itself. The simplest vacuum gauge is the McLeod mercury gauge.

One of the disadvantages of the McLeod gauge is that it is not continuously reading, in other words, the mercury has to be raised and lowered continuously to obtain readings. The electrical type gauges are much easier to read since they give a continuous indication of pressure. One of the most common electrical gauges is the thermocouple gauge in which a wire is heated by a constant current and the temperature of the wire is measured by means of a thermocouple. The higher the pressure, the more gas will be available at the wire for removing the heat from that wire. However, when a vacuum of the order of one millionth of an atmosphere has been reached, the variation in pressure no longer affects this gauge. Types of gauges based on electron emission operate in the same fashion as vacuum tubes where current flow is determined by the amount of gas present.

### *Applications*

One of the first applications of vacuum melting and probably the most widespread use at this time is vacuum induction melting. A vacuum induction melting furnace is really nothing more than a standard induction melting furnace enclosed in a steel tank containing also all the molds and other necessary accessories. The larger furnaces of this type in operation to date can handle approximately one ton maximum of steel. However, it is interesting to note that furnaces at the present time are being developd to handle capacities up to five tons, and which will have a power rating of as much as 2500 kilowatts. The power used will normally be 60 cycle or in the low machine frequencies.

Another type of furnace frequently used for vacuum induction melting, especially in the uranium industry, is the Micarta tube induction melting furnace. The only difference between this and the vacuum induction melting furnace is that the vacuum tank is made of a nonmetallic material with proportionally lower electrical losses and a much smaller over-all size. Such a furnace may be tilt-poured (where the whole furnace is tilted and the material is allowed to flow into the mold) or bottom-poured (where a special type of plug releases the molten metal into a mold suspended at the bottom of the furnace). (Fig. 3).

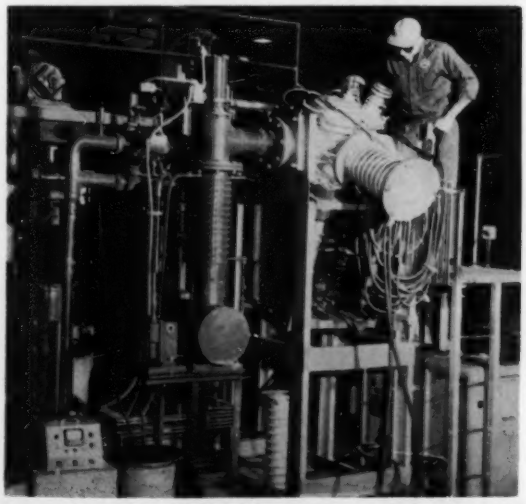


Fig. 3—This shows a Micarta® tube induction melting furnace being tilt-poured. The mold is contained in arm at the top of the furnace and is also under vacuum.

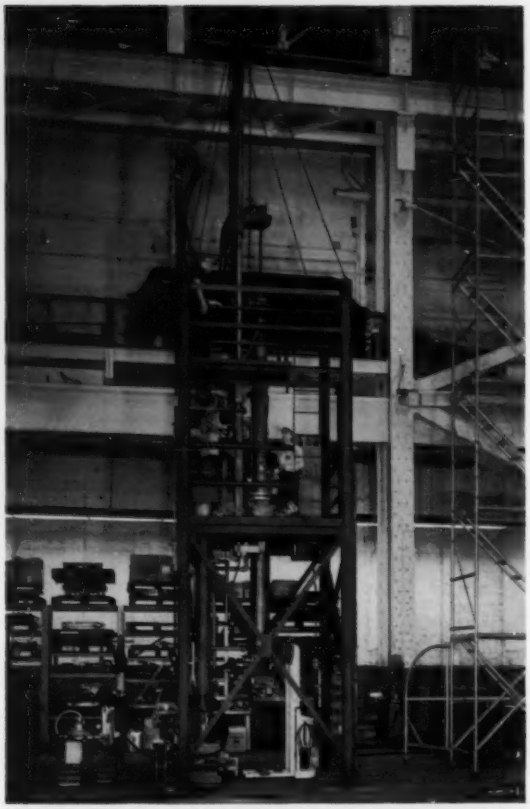


Fig. 4—Shown here is an overall front view of an eight-inch, two-electrode furnace.

Also used for vacuum melting is a skull melting furnace. The material can be melted either by an electric arc or an induction coil. The main feature is that the molten material is contained within a water-cooled copper crucible to prevent contamination of the material by the crucible itself. When the material has been melted, it is poured into a mold.

Another method, commonly known as vacuum pouring, was developed recently in Germany. Several large installations are being operated now in the United States and the main application is the fabrication of large rotor forgings. In this application, steel from an open hearth or electric furnace is simply poured into another ladle or ingot mold under vacuum. In this fashion, the molten metal is being outgassed while it pours. No information is yet available to determine if this method will provide better quality of rotor forgings.

Vacuum arc melting is a new melting process which is spreading extremely rapidly. It was introduced first into the United States with the melting of titanium, which is still the largest use to date for vacuum arc melting furnaces. Vacuum arc melting furnaces are basically of two types. Type one is called a nonconsumable arc melting furnace. (Melt material is fed continuously into the arc through a vibrating type feeder). The arc is struck between the electrode and

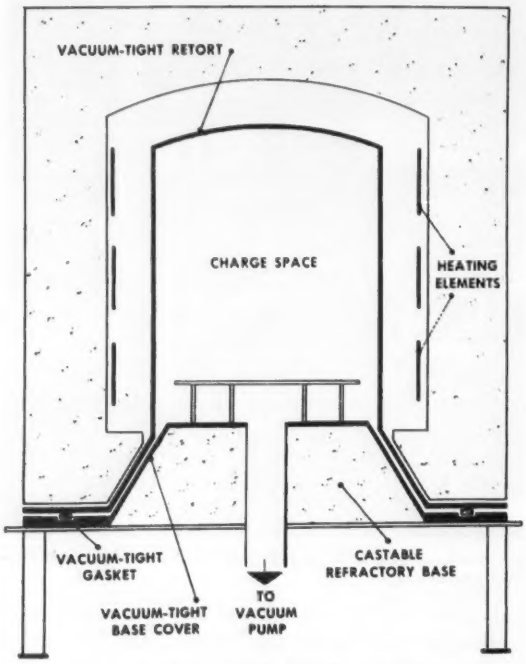



**Fig. 5—Here is a drawing showing the principles of a bell-type furnace such as used for annealing steel or copper.**

material being dropped into the ingot mold. As soon as the material melts, it freezes on the wall of the water-cooled copper crucible. In the second type called a consumable electrode arc melting furnace, the material to be melted is actually the electrode. The electrode itself therefore melts into the crucible and forms an ingot. In this type of furnace, all the power is generated just to change one electrode into a larger ingot of the same shape. There is a good reason for doing this. The metal is being purified during the process.

Some of these furnaces require great flexibility. For example, a typical negotiation drawing on a furnace for uranium and other hush-hush alloys would show a combination of both consumable and nonconsumable electrode furnaces. In general, the control panels will be remote because of the danger of explosion associated with these furnaces. An explosion might occur if the arc from the electrode leaves the ingot and strikes the water-cooled copper wall and the water comes into the furnace and reacts with the molten material. Proper control of the arc makes this danger, negligible. Fig. 4 is a front view of an eight-inch, two-electrode furnace.

In addition to removing gases from the molten metal, this furnace has another advantage which is the very rapid freezing of the molten material preventing the metallurgical phenomenon known as segregation in which various constituents separate within the ingot. One of the problems being very seriously investigated today is the vacuum arc melting of the very large forgings to be used for rotating equipment where better ingots are badly needed. It is felt that controlling the cooling rate in a vacuum arc melting furnace of the type described here can solve the problems which have been blamed for the failure of some large generators.

From the electrical standpoint, a vacuum arc melting furnace is quite simple and is nothing more than a d-c arc. Power is obtained from standard welding rectifiers connected in parallel and producing heavy currents up to 30,000 amperes. The normal voltage of the arc under vacuum, which is quite difficult to control, varies between 20 and 40 volts.

The earliest vacuum furnaces were nothing more than standard box furnaces, into which a retort was placed. In a furnace of this type, the work has to be placed in position inside the retort which is not always an easy thing to do. Fig. 5 shows a bell-type furnace which is very similar to the furnaces normally used for annealing steel or copper. The retort on this furnace can be lifted by means of a crane, exposing the work on the charge space.

The major disadvantage of the standard furnace is the fact that at high temperature the retort softens and tends to collapse under the action of atmospheric pressure. Under those conditions a double

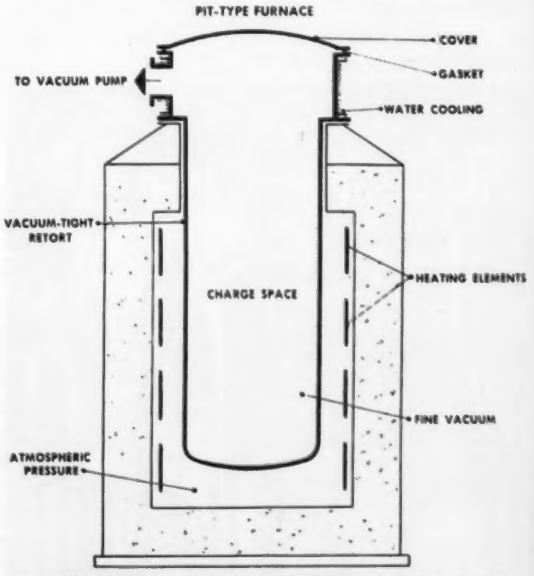
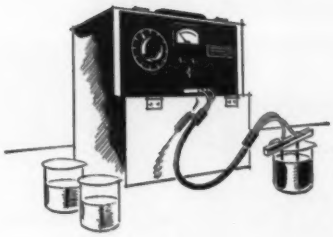



**Fig. 6—This shows a pit-type furnace that can be double-pumped: a fine vacuum inside the retort; a rough vacuum between the retort and the furnace shell.**

*(Continued on page 60)*



# "Quenchol Demonstrator showed...They needed More Cooling Power to stop spotty hardness!"

A large manufacturer of locking pins recently had a problem getting uniform high hardness on SAE 1074 steel. Hardnesses varied from 34 to 61 $R_c$ Hardness. Since this and other factors pointed to the competitive oil they were using, they asked Sinclair Representative Russell Smith for his evaluation. Mr. Smith reports:

"Spotty hardness indicated that the oil being used lacked cooling power. A comparison test on the Sinclair Quenchol Demonstrator showed that this oil had a cooling power rating of 784 . . . as compared with a rating of 1225 for QUENCHOL 521!"

## This test convinced them!

Mr. Smith continues, "The Quenchol Demonstrator test results persuaded this manufacturer to install QUENCHOL 521 immediately. Now they are getting an increased and uniform hardness range of 59 to 65 $R_c$ Hardness. Moreover, with QUENCHOL 521 *working loads have been increased 67%*, from 3 tons to 5 tons per quench, using the identical equipment and procedures! Needless to say, this manufacturer is very pleased with the cooling power and performance of QUENCHOL!

Try a FREE Quenchol Demonstrator test on *your* present quenching oil. See how it compares with the amazing cooling power of QUENCHOL 521. Make arrangements through your local Sinclair Representative, or write to Sinclair Refining Company, Technical Service Division, 600 Fifth Avenue, New York 20, N. Y. Free literature is available, and there is no obligation.

**SINCLAIR**

**METAL WORKING OILS**

# STRESS RELIEVING SIMPLIFIED WITH MULTIPOINT TEMPERATURE RECORDER

*By* **Ralph M. Stotsenburg,** *Sales Manager*
*Fielden Instrument Division*
*Robertshaw-Fulton Controls Company*
*Philadelphia, Pennsylvania*

THERMAL stress relieving is mandatory on boilers and pressure vessels which have been subjected to certain structural changes as the result of welding, torch cutting, etc. (Section VIII, Sub B UW10-1952 ASME Code for Boiler and Pressure Vessels.) This operation is performed in accordance with the requirements established by the Code. One of the principal methods used for such treatment is the application of heated gases within the container.

However, internal heating of the vessel by any appropriate means is allowable if used in conjunction with adequate indicating and recording temperature devices to aid in the control and maintenance of a uniform distribution of temperature in the vessel wall.

This approach to stress relieving has been successfully practiced by one major industrial company by incorporating a (24 point Tektolog) recorder-controller manufactured by Fielden Instrument Division of Robertshaw-Fulton Controls Company. (See Fig. 1).

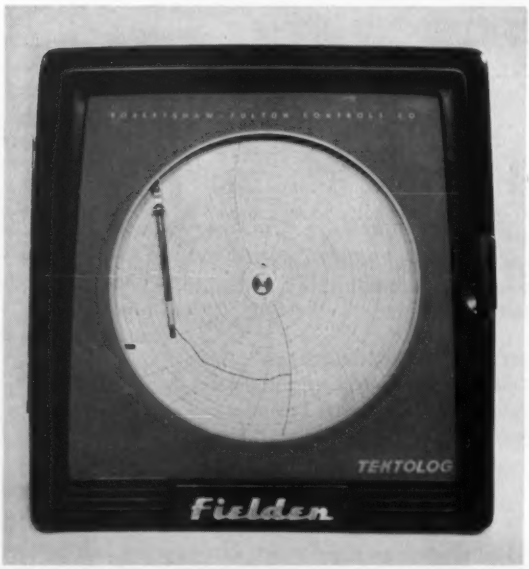



**Fig. 1—A 24-point Tektolog recorder-controller manufactured by the Fielden Instrument Division of Robertshaw-Fulton Controls Company. The mechanism prints 24 individual records on a standard size circular chart.**

The need for a multiple recording and controlling device can be best explained by describing the process and the many critical factors which require the constant vigilance of the men in a manufacturing plant.

The vessel is fully enclosed with suitable insulating material which will minimize heat loss as a preliminary preparation. Hot gases from a furnace, so designed as to allow no direct impingement of the flame on the vessel, are fed into the container which is heated up to 600°F. Above 600°F., the rate of heating must be regulated so that it is not more than 400°F. per hour divided by the maximum metal thickness of the shell in inches (but not greater than 400°F. per hour in any case).

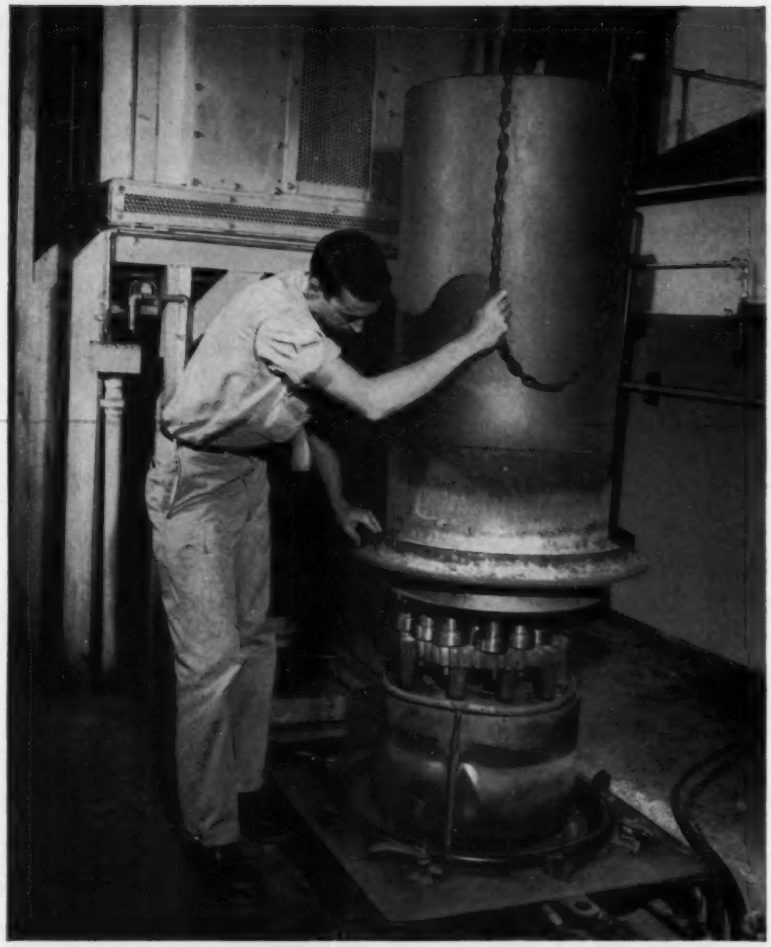
During the heating period, there may not be a variation in temperature throughout the portion of the vessel being heated larger than 250°F. within any 15 ft. interval of length, and when at the holding temperature, a variation of not more than 150°F. throughout the portion of the vessel being heated. A minimum temperature of 1100°F. (at which the residual stresses are relaxed) shall be maintained for a period of one hour per inch of metal thickness (maximum metal thickness of the shell or head plate). During the heating and holding periods, the furnace atmosphere shall be so controlled as to avoid excessive oxidation of the surface of the vessel.

Above 600°F., cooling must proceed at a rate not greater than 500°F. per hour divided by the maximum metal thickness of the shell or head plate in inches, but in no case more than 500°F. per hour. From 600°F. to ambient the vessel may be cooled in still air.

In this procedure the internal pressure is kept as low as practicable, but must not be greater than 50 per cent of the maximum allowable working pressure at the highest metal temperature expected during the stress relieving period.

At well-distributed points on the vessel wall where the temperature measurements are desired, a total of 14 metal blocks are welded vertically. (See Fig. 2). Two thermocouples are peened into each block; one reserved as an auxiliary. The thermocouple blocks remain on the vessel and whenever testing is necessary, the recorder is simply connected to the couple. One

*(Continued on page 20)*



# Unruffled Muffle!

## ...this Inconel retort takes 15 heating cycles per week...up to 2100°F

About two years ago, Fabriform Metal Products Company, Los Angeles, installed this Inconel* nickel-chromium alloy muffle for the copper brazing of aircraft parts.

Ever since then, the muffle has been through an average of 15 heating cycles a week.

And not easy cycles, either! Heat from room temperature to 2100°F ... hold at temperature for 45 minutes ... then cool to room temperature again!

The special properties of Inconel alloy account for the excellent performance of the muffle which was designed and fabricated by California Alloy Products Company, Los Angeles. For example, Inconel easily resists the atmospheres inside (mostly dry hydrogen ... occasionally, dissociated ammonia) and the tendency toward oxidation externally at this very high temperature. Inconel also has good high-temperature strength ... shows little distortion.

Inconel proved easy to fabricate, too. The original muffle was formed and welded without trouble. Later, after 8 months' severe service, the old top was cut off and a new top welded on by Cal Alloy with equal ease.

Get full details about the many advantages and economies of Inconel. Write for a free copy of "Keeping Costs Down ... As Temperatures Go Up." *Registered trademark

**The International Nickel Company, Inc.**
67 Wall Street New York 5, N. Y.

INCO TRADE MARK **Nickel Alloys**

**Inconel**... *for long life at high temperatures*

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## ANHYDROUS AMMONIA

Anhydrous Ammonia (Refrigeration grade) is a chemical compound which yields a low dew point mixture of hydrogen-nitrogen for furnace atmospheres when dissociated.

Often where 100% hydrogen concentration had been used for furnace atmosphere, it is now known that lower concentration of hydrogen with pure nitrogen as the carrier gas is available. Anhydrous Ammonia is the most economical raw material for this process as distributed by Hamler Industries.

*Use Dissociated Ammonia for the Following Metal Treating Applications:*

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You do not have to own storage equipment in order to get Ammonia by the Hamler Industries System. We will *furnish* you with a pressure tank, completely equipped with all gauges, excess flow valves, dual pressure relief valve assembly, designed and pressure-tested to conform with all state and city codes for unfired pressure vessels.

Learn more about our system—our technical men are always ready to assist you and give you detailed information.

*We invite your problems. For these details please call or write your nearest Hamler office.*

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*99.995% Pure*

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## STRESS RELIEVING SIMPLIFIED

(*Continued from page* 18)

couple installed in the inlet and another in the exhaust apertures complete the necessary coupling to insure accurate average temperature readings on the recorder.

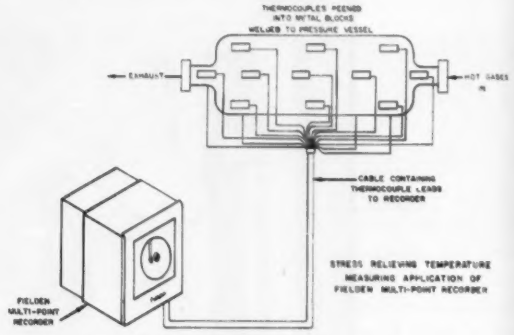
THERMOCOUPLES PEENED INTO METAL BLOCKS WELDED TO PRESSURE VESSEL
EXHAUST
HOT GASES IN
CABLE CONTAINING THERMOCOUPLE LEADS TO RECORDER
STRESS RELIEVING TEMPERATURE MEASURING APPLICATION OF FIELDEN MULTI-POINT RECORDER
FIELDEN MULTI-POINT RECORDER

**Fig. 2—A function diagram and chart showing the stress relieving temperature measuring application of the multi-point recorder.**

The recorder is equipped to permit automatic control of the heat, but manual control may be administered where most desirable. ■■■

**For accurately measuring flow rate of air and gases**

***The new, improved Series F Selas***

**FLO-SCOPE**

***In metals, ceramics, glass, food processing . . . in virtually every industry . . . you get these benefits:***

- **Quick, easy panel or "in-line" mounting.**
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**SELAS** CORPORATION OF AMERICA, DRESHER, PENNSYLVANIA
*Heat and Fluid Processing Engineers*
DEVELOPMENT • DESIGN • CONSTRUCTION

(Continued from page 4)

vertical position small, cylindrical printing rolls for a low-temperature stress relief. The specialized units keep the parts separate and in the proper position. The rolls are taken from the previous operation and passing through the furnace are delivered cool and in sequence to the next operation. A standard box-type tempering furnace could do the job, but wouldn't insure delivery of the parts to the operator in the desired place at the right time and damage could be caused by the added handling.

Similarly, a furnace for preheating strips of plastic insulating laminae has been made. It has a vertical feeding arrangement and an automatic ejector to slide out the bottom piece as required by the operator. This job could be done in a batch furnace too, with special precautions, but this single-purpose unit greatly simplifies the operation, speeds up production and keeps the parts in the desired position.

Special handling may then demand a special furnace and the amount of production will establish it. The more drastic the handling requirement, the less the amount of production necessary to justify the purchase of a specialized unit.

### *Protective Atmospheres Become Essential for Many Applications*

The need for protective atmospheres has been greatly emphasized in the desire to eliminate cleaning and machining operations. The use of such atmospheres is even more important since they show their influence on the physical properties of the finished work.

Actually, there are many operations which do not require the use of such atmospheres, such as the heat treatment of rough forgings or rolled stock where there is already scale and decarburization present. It is assumed that there will be subsequent machining or grinding operations which will remove this surface, and hence, the use of atmosphere at this time generally is uneconomical. It is to be remembered, however, that even under those conditions atmospheres are sometimes practical because of the quantities of loose scale deposited by these parts in a non-atmosphere furnace and in the quench tank all of which makes frequent cleaning necessary.

Atmospheres are essential today because most tools and machine parts are finished to size or very nearly so. To provide the designed physical properties, scale and carburization or decarburization must be prevented. Tools with cutting edges, such as machine knives and gears with wear-resistant working surfaces, must retain the correct surface carbon content to insure the desired performance. Use of the proper atmosphere in a furnace designed for that atmosphere, insures it.

(Continued on page 29)

*The*

*Metal Treating Institute*

## *Annual Achievement Award*

***The award is made at the discretion of a Committee appointed to select the Best Article appearing in METAL TREATING magazine or Lecture presented at any meeting of the Institute.***

***This year's award shall be presented at the 1957 Annual Meeting of the Institute, and all Articles appearing in any issue of METAL TREATING from September-October 1956 to July-August 1957 or any Lectures presented at the 1956 Annual and 1957 Spring Meetings are eligible for consideration.***

**Award Committee—**

**H. N. Bosworth, *President, Metal Treating Institute***

**H. C. Knerr, *Chairman, Publication Committee***

**L. G. Field, Fred Heinzelman, Jr., N. R. Hodgson, K. U. Jenks, Michael Kober, C. R. Weir; *members, Publication Committee***

**C. E. Herington, *Editor, METAL TREATING***

# Right Or Wrong In

## LABOR RELATIONS

**Editor's Note:** *This department presents, in each issue, a round-up of day-to-day in-plant problems and how they were handled by management. Each incident is taken from a true-life grievance which went to arbitration. Sources of these cases will be given upon request.*

### *Can You Fire a Worker Who Said He Was Out Sick When He Wasn't?*

***What Happened:***

A few hours before his shift started, Robert Wilson phoned a couple of his friends at the plant. He asked them to report him sick that day and the next as he had to drive a friend to Washington. The foreman called Wilson's lodging to find out if he needed any help. On learning that Wilson wasn't in, the foreman left a message for him to call back. The next day, the foreman phoned again, and again was told that Wilson wasn't in and that he had not picked up the previous day's message.

The foreman became suspicious. He questioned the workers who had reported Wilson "sick" and got the whole story. When Wilson got back, he was fired. Wilson felt this was altogether too rough. He argued:

1. A man is innocent until he's proven guilty. The foreman hasn't proved that I wasn't sick.
2. The rule is I can't be fired without a warning—and I didn't get any warning.
3. Other employees have done the same—or worse—and they didn't get canned.

The foreman's answer was:

* It's pretty darn clear that Wilson wasn't sick.
* If the worker hadn't been found out, he could have collected sick pay he wasn't entitled to. That's dishonest.
* Maybe it is the custom, but there's nothing in the contract that requires a warning notice before discharge.

Was the Foreman: RIGHT ☐ WRONG ☐

***What Arbitrator David Stowe Ruled:***

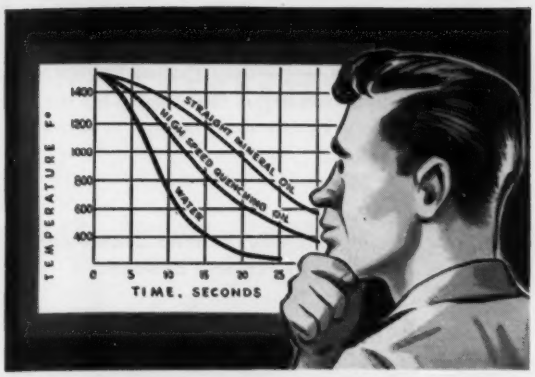
"It is reasonable to conclude that there were reasons other than illness for Wilson's absence. It constituted a misuse of the sick leave privilege and the company had sufficient justification for taking some disciplinary action. The Referee finds no restriction in the contract that requires that a discharge must be preceded by a warning. The only restriction is that the discharge must be for just cause. Mr. Wilson's record with the company is entirely clear of any previous indication of disciplinary trouble. The company had the choice of several degrees of disciplinary action which would have been less drastic for a first offense, and at the same time would have have been severe enough to prevent its recurrence. While Wilson *was* guilty of misuse of sick leave, in light of his past good record and in light of the disciplinary actions normally taken in offenses of an equally serious nature, the penalty of discharge in this case is too severe. The company shall reinstate Robert Wilson to his former position with full seniority but without any pay for time lost."

### *Can You Fire a Worker for Threatening a Foreman?*

***What Happened:***

Foreman Parrish came into foreman Brown's de-

*(Continued on page 24)*



**1. Quenching Speed.** There are two basic types of quenching oils...straight mineral oils and compounded high-speed oils. If you can get the microstructure and hardness you need and have no distortion problems with a straight mineral oil, then it's the type to use. If you're not getting the results you want, increased agitation may help. If increased agitation doesn't help, or isn't practical, you should use a high-speed oil.

**2. Naphthenic vs. Paraffinic.** Both types of oil are used for quenching. Both have their own inherent advantages. Naphthenic oils keep oil coolers cleaner when the temperature of the oil doesn't exceed 150 F. A fully dewaxed paraffinic oil gives the most satisfactory results at temperatures over 150 F. As a rule, when all other operating factors are equal, the temperature of your oil bath tells you which type of oil to use.

# What's the difference in quenching oils?

**3. Thermal Stability.** This is the biggest single factor influencing the useful life of a quenching oil. The higher the temperature of the oil bath, the shorter the life of any given oil. As mentioned before, at temperatures over 150 F it takes a stable, fully dewaxed paraffinic oil to give the most satisfactory results. For maximum useful life at temperatures over 200 F you will probably need a specially inhibited quenching oil.

**4. Other Considerations.** When quenching from a salt pot, use a straight mineral oil. Don't use an oil containing lard oil or other vegetable or animal fats. The salt carried into the oil on the parts will cause these fats to saponify and form oil-thickening grease. For bright quenching, experience shows that a straight mineral oil will give the best over-all results. For the most part, a straight oil will give cleaner parts longer.

These facts are nothing more than a guide to help you select the quenching oil best suited to your particular needs. To arrive at the final answer, there's no substitute for experience. Sun's representatives, backed up by Sun's metallurgical staff, have that experience. And, they're backed up by a *complete* line of quenching oils, paraffinic or naphthenic, regular or high-speed, straight or inhibited. Sun makes them all. For more information, see your Sun representative or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MR-3.

**INDUSTRIAL PRODUCTS DEPARTMENT**

**SUN OIL COMPANY**

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SUNOCO®

## RIGHT OR WRONG

(*Continued from page 22*)

partment and asked to borrow an extension cord. "Sure, help yourself," Brown said. "Take any one that isn't being used."

Parrish walked over to Bill Winter's bench and picked up an extension cord which was lying there. "Don't you touch anything on my bench!" yelled Winter, jerking the cord out of Parrish's hand. "Or you won't live to use it!"

"Well, if that's the way you feel about it . . ." said Parrish, and released the cord. As Parrish walked off, Winter shouted an obscene four-letter word after him. Later that day, Winter was fired. He protested, and when the matter came to arbitration he maintained:

1. All I did was make a mild protest about Parrish's habit of walking off with things anytime he felt like it.
2. Parrish and Brown had it in for me for a long time, so it wasn't fair to take their word against mine about what happened.
3. Other workers have had fist fights on the job, and not been fired.

The two foremen answered:

1. That was no mild protest. Winter made such a racket that he attracted everybody's attention, in spite of the noise of the machinery.
2. Winter must have a persecution complex. We never even discussed him between ourselves before the incident.
3. Fighting with other workers is one thing. Yelling threats at a foreman is something else again—and much more serious.

Were the Foremen: RIGHT ☐ WRONG ☐

***What Arbitrator Walter Boles Ruled:***

"The Arbitrator has no choice except to find that grievant did voice a threat to Mr. Parrish's life. Threats of bodily harm are, of course, to be avoided at all times. But this is especially so where a supervisor and supervised are concerned. No business enterprise can be expected to function effectively if those supervised threaten and revile their supervisors. Order and discipline and productivity and morale disappear under such circumstances. If it had been established that in other instances employees had been involved in equally serious incidents with supervisors and had not been discharged, the Arbitrator would have had something on which to base a finding of 'discrimination.' But the cases cited to support this contention involved altercations between employees. All other things being equal, the threat to general discipline in a work situation is much less serious when Employee A pokes Employee B than when Employee C makes an unprovoked attack on Supervisor D. And it is realistic and proper (having in mind the use of disciplinary action as a deterrent to future infractions), that the disciplining of Employees A and B for their hassle should be less severe than that of Employee C for attacking Supervisor D, or threatening his life, or cursing him. The grievance must be, and is herewith, denied."

### *Can You Discipline a Worker Who Leaves Early to Take Care of Personal Business?*

***What Happened:***

About an hour before quitting time, Leadman Andy Jaeger got a phone call at the plant that his brother had to be driven to the hospital. He asked Foreman Dore to give him a pass because he had to leave. He didn't say why. Dore was short-handed, and refused. Jaeger made a couple of phone calls trying to get a friend to drive his brother to the hospital. No soap. Again he asked Dore for a pass. Dore said, "It's got to be darned important for me to give you one."

Jaeger said, "It *is* important. I've got to leave," but he still didn't say why, and Dore again refused. Jaeger left anyway. Next day he got a three-day suspension. He claimed it was unfair:

1. I've worked here fifteen years, and I've never broken a rule before.
2. I told the men under me how to carry on until quitting time so the work didn't suffer.
3. Foremen usually give passes to workers for urgent personal business without pressing them for details. It was unfair to refuse me.

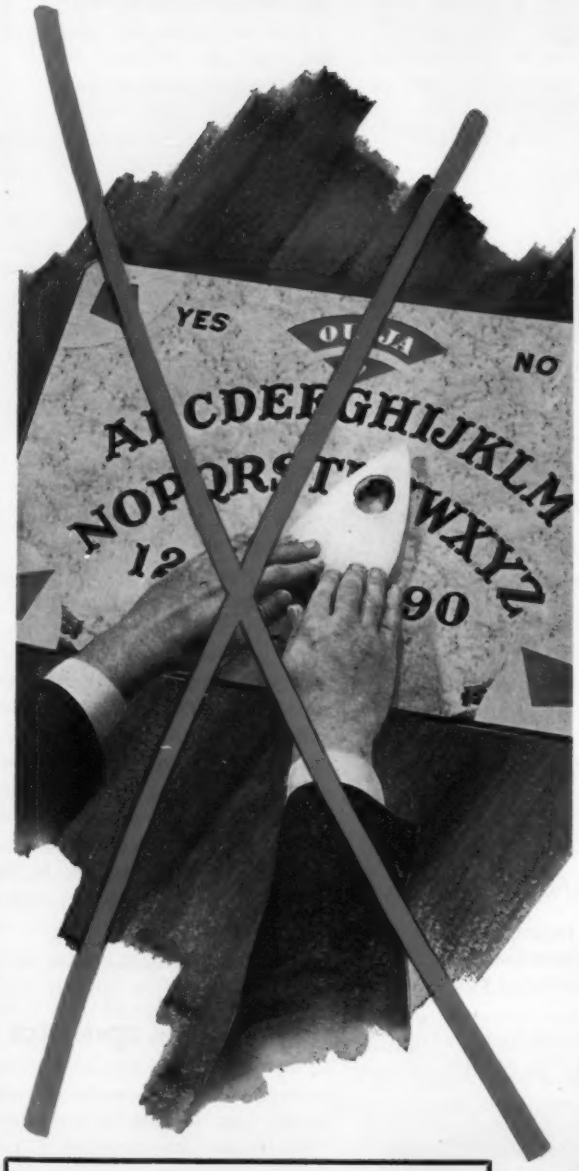
The foreman's answer was:

* Jaeger should have been specific about what was so urgent.
* He could have gone to the superintendent or got his steward to help him. There was no excuse for just walking off without a pass.
* I've taken his good record and all the rest of it into account. A three-day suspension is a very mild penalty for breaking a well-known plant rule against quitting early without permission.

Was the Foreman: RIGHT ☐ WRONG ☐

(*Continued on page 59*)

# Ouija boards are passé




Time was, when a person had a question, out would come the ouija board for an answer. This wasn't too accurate a system, of course . . . but a lot of people put a lot of faith in what the ouija board told them.

Times change — and today accuracy is the keyword. That's why the modern business publication wants its circulation audited.

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# NEWS TO HEAT TREATERS...

## AUTOMATIC TEMPERATURE CONTROL

Three-position pryometer temperature controllers are now being offered for many applications by West Instrument Corporation of Chicago. These controls are easily wired for a wide variety of specialized control applications: heating with automatic cooling; motor operated fuel valve; Hi-Lo Off or Hi-Lo-Med electric or fuel systems; control with High Limit feature and automatic reset.

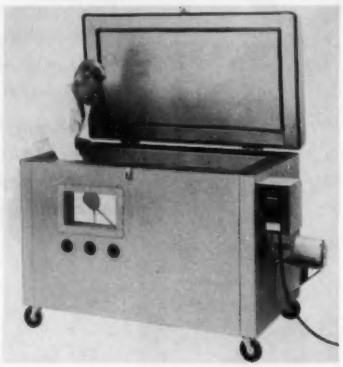
They are used with plastic extruders, industrial ovens, furnaces, etc. They provide for two types of neutral band, each with two types of control. One, with a single setting pointer, permits no more than 1% of scale range as neutral. The other, with two settings, permits spread up to 20% of range. On-off or proportioning type control available. All models are free from vacuum tubes.

***For further information circle No. 1***

## HIGH-LOW TEMPERATURE CHAMBER

A new, self contained, automatically controlled high-low temperature chamber for treatment of metals and various other production materials, as well as for multi-environment testing of materials, components, instruments, etc., has been announced by Mantec, Inc., El Segundo, Calif.

Pre-selected temperatures ranging from −100° F to +400° F are automatically produced and maintained with ±2° F during continuous operation. The chamber temperature can be dropped to −65° F in 40 minutes or raised to +400° F in 30 minutes, starting at room temperature.



Low temperatures are generated by dry ice placed in a special compartment. A motor driven fan circulates air over the ice. Refrigerated air then passes through the working volume in a double convection system. During operation temperature is automatically held to ±2° F of the control point. High temperatures, selected by a 3 wattage switch, are supplied by an electric heating element.

***For further information circle No. 2***

## NON-INDICATING POTENTIOMETER CONTROLLERS

The Wheelco Instruments Division of Barber-Colman Company announces the availability of two new non-indicating controllers.

The controllers are potentiometer type units designed for those control applications encountered in batch process work. Typical applications include salt baths, pickling tanks and similar industrial equipment. They employ a circuit in which the unknown voltage is connected in opposition to a known voltage with any difference used to actuate the control circuit. The sensing element, a thermocouple, supplies the unknown voltage in the circuit. A known voltage of a value corresponding to the control point desired is imposed from a separate source to the other side of the circuit. The difference between these voltages is fed into a saturable core reactor.

This saturable core reactor amplifies the difference between the unknown and the known voltages and operates in such a manner that when the known voltage exceeds the unknown the amplified difference controls the firing of a thyratron. When the voltage output of the sensing element reaches a value giving null balance, no current flows to the reactor, and the thyratron, is "cut off". In this manner, the circuit to the control relay is de-energized.

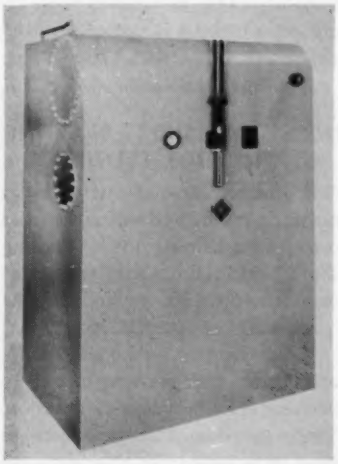
***For further information circle No. 3***

## EXOTHERMIC GENERATOR

Operating with any of the common gases, a new exothermic generator just released by Sargeant & Wilbur, Inc., Pawtucket, R. I., produces atmospheres ranging from 10% $O_2$ to 11% CO without catalyst change. They are already marketing the new generator in capacities up to 10,000 C.F.H. and are prepared to supply larger sizes on request.

The makers report that the new equipment's streamlined appearance and simplicity of operation give it strong appeal to industry.

Servicing and operation have been simplified to the extent that no technical knowledge whatsoever is required. Newly designed cooling



has greatly increased efficiency and has reduced replacement cost by nearly 50%,—as proved by the exhaustive tests to which the generator was subjected before its introduction to the market.

***For further information circle No. 4***

## NEW HEAT TREATING DIVISION

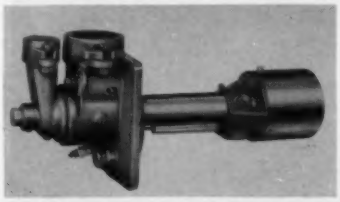
Loftus Engineering Corporation of Pittsburgh, Pennsylvania, for many years designers and builders of open hearth furnaces and other steel mill equipment, recently established a Heat Treating Furnace and Oven Division in Chicago. The Pittsburgh division is now devoting itself exclusively to the designing and building of steel mill equipment and induction furnaces

The Chicago division was established in April, 1956, in order to provide better customer service on the engineering and building of heat treating furnaces and other shop fabricated units. The Loftus group in Chicago now handles all types of heat treating furnaces and ovens, including non-ferrous melting equipment.

***For further information circle No. 5***

## GAS BURNERS FOR RADIANT OR IMMERSION TUBES

New "RTG" Burners developed by Hauck Manufacturing Co., Brooklyn, N. Y., have been designed to provide control of flame length to fit the length of radiant tubes and give better heat distribution. A primary air adjustment



feature permits the burner application to a full range of tube sizes.

Because the major portion of combustion air is introduced around the outside of the flame retention nozzle, the burner operates more quietly. This diverted air flow helps prolong combustion over a greater length to get best heat distribution. All of the air for combustion is supplied through the "sealed-in" burner, eliminating need for an eductor or exhaust fan. The burner permits a turndown ratio of 5 or 10 to 1.

The burner includes a mounting flange with integral air inlet body, flame length control lever and indicator dial, direct spark ignition for easy, quiet lighting of burner (no pilot required), observation


YOUNG BROTHERS OVENS and FURNACES

Electrically heated, controlled atmosphere furnaces.

for Greater *ECONOMY* and *EFFICIENCY* in **HEAT TREATING**

Young Brothers Ovens and Furnaces are the product of 60 years of experience in building ovens and furnaces for all heat treating processes. As a result they operate more efficiently, turn out more and better production and meet the exact requirements for which they are engineered.

Knowing the basic problems of heat treating, Young Brothers Engineers have perfected ovens and furnaces that operate reliably, provide large savings in fuel and handle a wide variety of work requiring a broad range of temperatures and heating cycles.

For better heat treating results in less time, at lower cost, investigate the exclusive advantages that Young Brothers Ovens and Furnaces offer. Write for Bulletin 14-T.

**YOUNG BROTHERS COMPANY**
1849 Columbus Road Cleveland 13, Ohio

# AMBUSHED!
## BY A DEFECTIVE POT

Immediate delivery from stock on 78 standard pots.

**It can't happen with low-cost Eclipse Pressed Steel Pots**

Sudden pot failure while your furnace is operating means costly damage to brickwork, burners, and controls, plus extended expensive downtime. It's a major blow to profits familiar to some users of cast pots. Now, however, there is no need to be ambushed by such losses. Eclipse Pressed Steel Pots cost only ⅓ as much as cast pots and you *cannot buy a defective pressed steel pot!* No defective steel survives the stresses of drawing. There can be no weld spots, stresses, cracks, or other critical areas to fail and flood the furnace. Visual inspection is completely dependable. You replace low-cost pressed steel pots on schedule *before* they fail. Drawn from firebox quality open-hearth mild steel — the heart of the ingot — these pots are not subject to grain growth at red heat. They weigh 50 per cent less than cast pots, have higher thermal conductivity, improve heating efficiency, save on fuel, increase productivity of your furnace. Take the *gamble* out of your heat-treating and metal-melting operations with Eclipse Pressed Steel Pots!

*Write today* for illustrated catalog and price list — details, dimensions of standard pots and Eclipse Metalized Pots for maximum protection from corrosive action of gases in high-temperature heat-treating. Metalizing can triple pot life.

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Eclipse Fuel Engineering Co. of Canada, Ltd.
20 Upjohn Road, Don Mills, Ontario

Eclipse® COMBUSTION EQUIPMENT
"Most complete line, anywhere!"

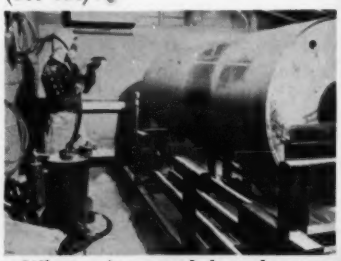

port for safe, easy viewing of flame, gas inlet body with primary air mixing adjustment, full flanged gas and air inlets and the burner nozzle assembly. The nozzle has supporting posts to keep it centered in the radiant or immersion firing tube.

***For further information circle No. 6***

## HOSE FOR SHOT BLASTING AND SHOT PEENING

Foundries, heat treaters, metal finishing plants and other activities using blast cleaning or shot peening should select hose with particular care according to engineers of the Thermoid Company, Trenton, N. J.

When sand is used for cleaning metal and other surfaces, the number one enemy of hose is abrasion. The tube should be composed of pure gum rubber so that the sand particles will bounce off. A static *wire* will control static electricity. (See cut).



When using metal shot, the greatest hose destroyer is static electricity. If not controlled the electricity will generate high voltage potentials which will burn through the tube and wall. The *tube* must, therefore, be compounded to conduct and dissipate electricity.

When both sand blast and shot blast or shot peening are used in the same shop, the hose should, of course, not be interchanged.

***For further information circle No. 7***

## HIGH NICKEL BRAZING ALLOYS

Handy & Harman, New York City, announces a series of four high-nickel content brazing alloys for high-temperature and corrosion-resistant service. These alloys, called Handy Hi-Temp alloys, are said to offer high strength at elevated temperatures and superior

*(Continued on page 35)*

## HOW TO SELECT EQUIPMENT

(*Continued from page* 21)

What atmospheres do you use? Exothermic reacted gas atmospheres are used to prevent scale on low carbon steels where decarburization is not a factor and are often used for copper brazing and non-ferrous heat treating operations. Exothermic atmospheres are produced by the direct combustion of mixtures of fuel gas and air at ratios which will burn without adding heat. A typical analysis would include 7% carbon monoxide, 7% carbon dioxide, 10% hydrogen, balance nitrogen with water vapor at a 70°F. dew point. Endothermic reacted gas atmospheres are used for all operations on steels requiring protection against scale formation, carburization and decarburization but because of the somewhat higher cost, do not usually replace the exothermic types for the operations previously mentioned. Endothermic atmospheres are the product of the cracking of mixtures of fuel gas and air at ratios which require external heat to complete the reaction. A typical analysis would provide 20% carbon monoxide, 40% hydrogen, 0.5% methane, balance nitrogen with water vapor at a 25°F. dew point. Dissociated ammonia and hydrogen are used to prevent oxidation on those materials where the presence of carbon cannot be tolerated, such as very low carbon electrical materials and particularly for those parts requiring the higher temperature ranges. There are other specialized atmospheres which might be applied to a particular problem.

Production quantities again will determine the need for atmosphere equipment. In batch operations the need to handle an occasional piece under atmosphere conditions can be fulfilled by packing the part in a box with cast iron chips or a suitable compound. This methods goes back many years, but the extra time and individual handling may be justified if there are infrequent demands for it and a typical non-atmosphere unit will suffice. It must be remembered that the cost of atmosphere furnaces is not only the cost of the atmosphere producer, but also the added cost of making the furnace tight. In fuel-heated equipment, it means isolating the products of combustion from the atmosphere by use of a muffle or radiant tubes which, of course, add to the cost of the unit.

### *The Furnace Must Conform to the Space Available*

The selection of furnace equipment may in some measure be affected by the space available and the location in the plant. If space is limited and conveyor equipment is indicated, it may be necessary to elevate the furnace. Another possibility is the vertical conveyor which carries the work on trays up one side and down the other. Generally, this would be limited to tempering, stress relieving and annealing operations, but could be adapted to other treatments.

(*Continued on page* 38)

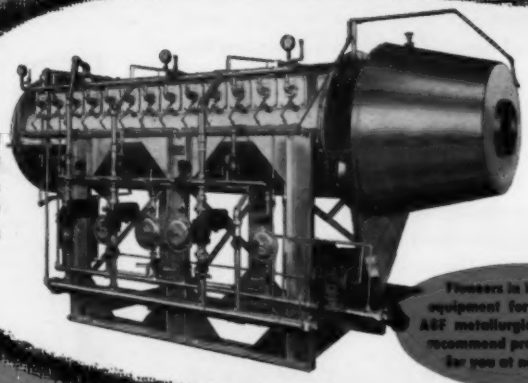

Controlled Atmosphere Heat Treating at the Lowest Unit Cost.

Use this continuous production furnace without modification for general and atmosphere work, including "Ni-Carb" ammonia-gas carburizing. Gentle tumbling action mixes the work and assures uniform heat treating.

Here are some of the many engineering improvements AGF Pioneers have made so that you can produce more pounds of work for every dollar invested in an AGF furnace. Less maintenance and operational cost than with any other furnace.

- Automatic self-metering feed hopper reduces work handling costs.
- Better control of processing atmosphere and temperature.
- Improved high production capacity combustion system.
- Increased thermal efficiency because only the work enters and leaves the furnace. Baskets, trays, chains and other troublesome mechanisms are eliminated.
- Alloy life is increased because the alloy remains within the furnace heating chamber at all times.

Improved AGF Continuous Rotary Retort Furnaces



Model 139-MD

Pioneers in heat treating equipment for ## years. Ask AGF metallurgical engineers to recommend proper equipment for you at no obligation.

Sizes in production capacities up to 800 pounds per hour. Representatives in principal cities.

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Send me your Bulletin No. 870 which will help me produce a quality product at lowest cost.

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COMPANY.....

ADDRESS.....

# HEAT TREATING HINTS

**Editor's Note:** *If you have any items of interest, please send them along.*

## Preheating—An Important Step in the Heat Treating Operation

Many times one hears the question asked, "Is it essential to include preheating as a phase of the heat treating operation for tools and dies?"

Metallurgically, preheating takes no part in the hardening reaction and in this regard it is not a necessary step; however, preheating usually is included in the treatment of all tool steels in order to minimize the normal hazards encountered in the heat treatment of these higher alloyed steels. There are two primary functions of preheating. The first of these is to reduce the thermal shock which is always obtained when a cold tool is placed directly into a hot furnace. The second function is to start the austenitizing reaction so that the carbides will be in a more favorable condition for dissolving at the high temperature. This latter function is particularly important in the heat treatment of high speed steels and those die steels requiring a hardening temperature in excess of 2000°F.

Because preheating reduces the thermal shock, it is beneficial in minimizing the danger of excessive distortion, warping and cracking. It serves as a stress relief of the internal strains set up during the machining operations, and if preheating is carried out just below the critical temperature, these machining stresses are relieved prior to beginning any transformation within the steel. Using one or more preheating steps also enables the tools to pass through the transformation range as uniformly as possible throughout the entire cross section. Since heating annealed steel to a temperature above the critical results in a decrease in volume, it is important for the tools to go through this phase change slowly and uniformly to minimize distortion.

Preheating of carbon and low alloy tool steel normally is carried out in the range of 1200-1300°F., high carbon-high chromium and other highly alloyed die steels at 1200-1450°F., and high speed and modified high speed steels at 1500-1600°F. If no protective atmosphere is available for the preheating step, the temperature should be adjusted to the lower side of the range to reduce the danger of developing excessive scale and decarburization. Double preheating at both 1000-1200°F. and 1500-1600°F. is often recommended for the treatment of intricate tools and dies, and particularly for high speed steel when treated in liquid baths.

Many times extra furnaces are not readily available for the preheating operations. In these instances, the tempering furnaces can be used for the preheating even though the available temperature may not be in the exact range desired. Even placing the tools on top of the furnaces or baths to warm them up will be some help in reducing the thermal shock. In all instances however, sufficient time should be allowed in preheating to permit the entire tool to attain a uniform temperature throughout.

Preheating is good insurance, and like insurance, it should be adjusted to meet the conditions at hand. ■■■

*Source — Latrobe Steel Company*

*"ARE YOU SURE YOU UNDERSTAND THE PROPER BLAST CLEANING PROCEDURE?"*

(*Continued from page 8*)

unstable condition. Such parts will, when heated during service to temperatures between about 250° and 800°F, transform partly to omega and become embrittled.

It was stated earlier that when deep- or intermediate-hardening alloys are given a solution heat treatment, the beta formed is retained if the quench is fast enough. If the alloy is then reheated for an age hardening treatment, the beta phase transforms to alpha by the following mechanism:

$$\beta \rightarrow \beta + \omega \rightarrow \beta + \omega + \alpha \rightarrow \beta + \alpha$$

The resulting dispersion of fine alpha particles in the beta matrix provides the high strength of the fully heat treated alloy. A representative age-hardening curve for this transformation is shown in Fig. 7. A

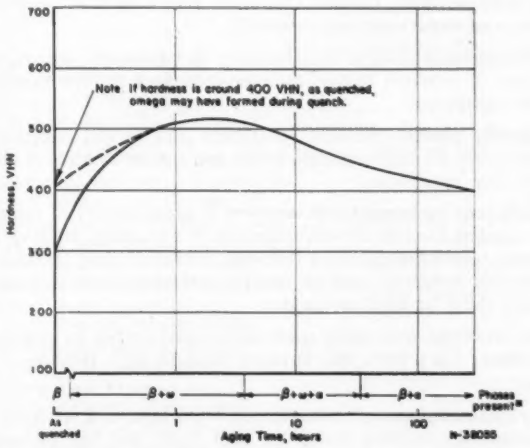



**Fig. 7—Representative hardness curve for an alpha-beta alloy quenched from alpha-beta field and aged at 800°F.**

schematic diagram of recommended quenching and aging practice to avoid or remove omega phase is shown in Fig. 8. The importance of a proper aging

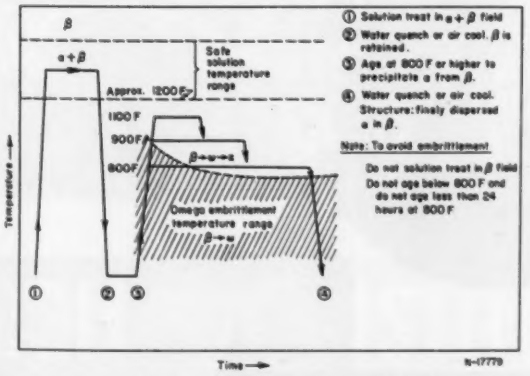

β
α+β
Safe solution temperature range
Approx. 1200 F
1100 F
900 F
800 F
β→ω+α
Omega embrittlement temperature range β→ω
① Solution treat in α+β field
② Water quench or air cool. β is retained.
③ Age at 800 F or higher to precipitate α from β.
④ Water quench or air cool. Structure: finely dispersed α in β.
Note: To avoid embrittlement
Do not solution treat in β field
Do not age below 800 F and do not age less than 24 hours at 800 F
Temperature
Time
N-17779

**Fig. 8—Recommended heat-treating procedure for alpha-beta titanium alloys which retain beta during a quench.**

treatment for air-cooled or water-quenched titanium alloy parts cannot be exaggerated. Aging for periods long enough to complete the transformation of omega to alpha is just as essential in fully heat treated parts as the proper stabilization treatment is for hot worked or annealed parts if embrittlement during service life is to be avoided. Although omega embrittlement is now very familiar to some metallurgists, it apparently is not understood by many who are working with titanium alloys. A recent problem involved a shipment of titanium alloy aircraft forgings worth many thousands of dollars. The parts were being held from production because they had strengths upwards of 190,000 psi, with 1 or 2 per cent elongation. Previous shipments had shown satisfactory ductility at a much lower strength level. Although the parts were supposed to be annealed before shipment, the chief reason for the high strength and poor ductility of these forgings was fast cooling rate. Reannealing the forgings and cooling slowly in the furnace raised the elongation to about 10 per cent with some sacrifice in strength.

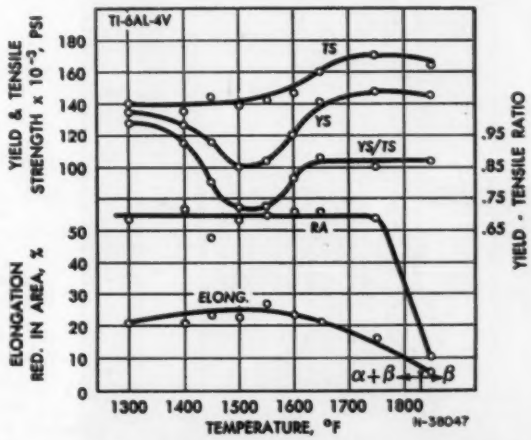



**Fig. 9—The effect of solution temperature on tensile properties of the Ti-6Al-4V alloy. Specimens held 1 hour at temperature and tested in the as-quenched condition. Note loss in ductility in specimens quenched from above the beta transus (12).**

### *Avoiding Loss of Ductility Resulting from Overheating*

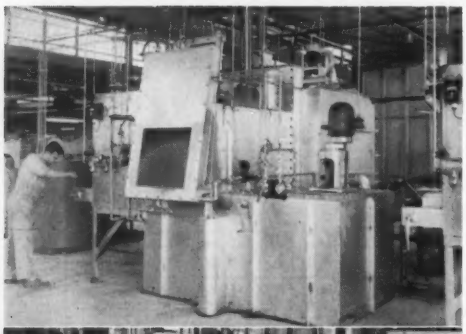
When titanium alloys are worked or simply heated above the beta transus, they suffer a loss in ductility.

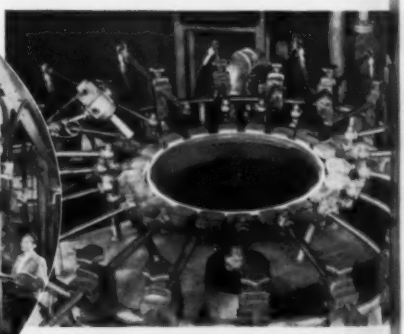
This is not to be confused with embrittlement resulting from beta instability and omega formation; it is, rather, attributed to excessive grain growth and gross microstructures. The ductility does not suffer so long as the alloy is in a low-strength condition. However, it becomes serious if the alloy is subsequently heat treated to ultimate strength levels above 130,000-140,000 psi. Examples of this type of behavior in two different alloys are shown in Figs. 9 and 10, respectively.

(*Continued on page 36*)

# WHEN IT COMES TO HEAT TREATING—
# "Do-It-Yourself" can sometimes be costly

*Buying equipment and supplies to perform heat treating operations within your own plant is only one step in many that must be considered when contemplating the installation or expansion of a heat treating department.*





Here are some of the factors that should be included when figuring the cost of operating your own heat treating department—of "doing it-yourself" when it comes to heat treating:

- **Technical skill:** Trained operators whose skill is the result of years of experience are essential
- **Maintenance:** Rapid deterioration of equipment occurs unless there is constant repair, maintenance, and skillful handling of the equipment
- **Quality control:** Testing equipment and skilled operators are necessary to maintain uniformity and quality control of all heat treating operations
- **Sufficient equipment and supplies:** A great variety of equipment is needed to meet the requirements of annealing, brazing, hardening, carburizing, stress relieving, nitriding, and all other heat treating processes; and an endless variety of materials and supplies must be kept on hand.

These problems and many more have been solved by commercial heat treaters. They have the answers because heat treating is their business.

Every MTI commercial heat treater listed here is a specialist with complete service facilities under one roof. Each one has the facilities, equipment, skill and experience which will enable him to meet your most exacting heat treating requirements.

*When you have heat treating problems or need heat treating services . . . write*

**METAL**

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## Consult these companies:

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**Hollywood Heat Treating Co.**
6902 Santa Monica Blvd., Los Angeles 38

**Lindberg Steel Treating Co.**
2910 S. Sunol Drive, Los Angeles 23

**Cook Induction Heating Co.**
4925 East Slauson Ave., Maywood

### CONNECTICUT

**Commercial Metal Treating, Inc.**
89 Island Brook Ave., Bridgeport 6

**Stanley P. Rockwell Co.**
296 Homestead Ave., Hartford 12

### ILLINOIS

**Senecca Heat Treating Co.**
124 S. Batavia Ave., Batavia

**Accurate Steel Treating Co.**
2226 W. Hubbard St., Chicago 12

**Dura-Hard Steel Treating Co.**
2112 W. Rice Street, Chicago 22

**Pearson Industrial Steel Treating Co.**
5757 W. Ogden Ave., Chicago 50

**Perfection Tool & Metal Heat Treating Co.**
1756 West Hubbard St., Chicago 22

**Fred A. Snow Co.**
1942 West Kinzie St., Chicago 22

**American Steel Treating Co.**
P. O. Box 225, Crystal Lake

**Eklund Metal Treating, Inc.**
721 Beacon St., Loves Park

**Lindberg Steel Treating Co.**
1975 N. Ruby St., Melrose Park

**O. T. Muhlemeyer Heat Treating Co.**
1531 Preston St., Rockford

**C. U. Scott & Son, Inc.**
1510 First Ave., Rock Island

### INDIANA

**Quality Steel Treating Company**
1630 Locust Street, Anderson

### MASSACHUSETTS

**New England Metallurgical Corp.**
475 Dorchester Ave., South Boston 27

**Porter Forge & Furnace, Inc.**
74 Foley St., Somerville 43

**Greenman Steel Treating Co.**
284 Grove St., Worcester 5

### MICHIGAN

**Anderson Steel Treating Co.**
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**Bosworth Steel Treating Co.**
18174 West Chicago Blvd., Detroit 28

**Commercial Steel Treating Corp.**
6100 Tireman Ave., Detroit 4

**Commonwealth Industries, Inc.**
5922 Commonwealth Ave., Detroit 8

**Michigan Steel Processing Co.**
3120 Denton, Detroit 11

**Standard Steel Treating Co.**
3467 Lovett Avenue, Detroit 10

**Vincent Steel Process Co.**
2424 Bellevue Ave., Detroit 7

**State Heat Treat, Inc.**
520 32nd Street, S. E., Grand Rapids 8

**Lincoln Heat Treat, Inc.**
21235 John R, Hazel Park

**Metallurgical Processing Company**
2703 East Nine Mile Road, Hazel Park

**Royal Oak Heat Treat, Inc.**
21419 Dequindre, Hazel Park

**American Metal Processing Co.**
12000 East Nine Mile Road, Van Dyke

### MINNESOTA

**Metallurgical, Inc.**
900 East Hennepin, Minneapolis 14

### MISSOURI

**Metallurgical, Inc.**
1727 Manchester Ave., Kansas City 8

**Lindberg Steel Treating Co.**
650 East Taylor Ave., St. Louis 15

**Paulo Products Co.**
5711 West Park Ave., St. Louis 10

### NEW JERSEY

**Ace Metal Treating Corp.**
611 Grove St., Elizabeth

**American Metal Treatment Co.**
Highway 25 and LaFayette St., Elizabeth

**Benedict-Miller, Inc.**
Marin Ave. and Orient Way, Lyndhurst

**Bennett Heat Treating Co., Inc.**
246 Raymond Boulevard, Newark 5

**L-R Heat Treating Co.**
107 Vesey St., Newark 5

**Temperature Processing Co., Inc.**
228 River Road, North Arlington

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**Alfred Heller Heat Treating Co., Inc.**
391 Pearl St., New York 38

**Lindberg Steel Treating Co.**
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**Rochester Steel Treating Works**
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**Syracuse Heat Treating Corp.**
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**Ferrotherm Co.**
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**Lakeside Steel Improvement Co.**
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**George H. Porter Steel Treating Co.**
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**Reliable Metallurgical Service, Inc.**
3827 Lakeside Ave., Cleveland 14

**Winton Heat Treating Co.**
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**J. W. Rex Co.**
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**Drever Company**
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**Lorenz & Son**
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**Metlab Company**
1000 East Mermaid Lane, Philadelphia 18

**Wiedemann Machine Co.**
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**Pittsburgh Commercial Heat Treating Co.**
49th St. and A.V.R.R., Pittsburgh 1

**Pittsburgh Metal Processing Co. Inc.**
1850 Chapman Street, Pittsburgh 15

### TEXAS

**Dominy Heat Treating Corp.**
P. O. Box 5054, Dallas

**Superior Heat Treating Co., Inc.**
P. O. Box 1686, Fort Worth 1

**Cook Heat Treating Co., of Texas**
6233 Navigation Boulevard, Houston 11

**Lone Star Heat Treating Corp.**
5212 Clinton Dr., Houston 20

### WISCONSIN

**Allied Metal Treating Corp.**
830 S. Fifth St., P. O. Box 612, Milwaukee 1

**Metal Treating, Inc.**
720 South 16th St., Milwaukee 4

**Supreme Metal Treating Co.**
4440 West Mitchell St., Milwaukee 14

**Thurner Heat Treating Co.**
809 West National Ave., Milwaukee 4

**Wisconsin Steel Treating & Blasting Co.**
1114 South 41st Street, Milwaukee 15

**Harris Metals Treating Co.**
4100 Douglas Ave., Racine

### CANADA

**B. & W. Heat Treating Limited**
70 Borden Ave., S., Kitchener, Ontario

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*or consult the M.T.I. members listed above*

# M.T.I. *Activities*

## MEMBERS PLAN SCHOOL FOR EMPLOYEES

Five commercial heat treating companies in Milwaukee, Wisconsin, all members of the Metal Treating Institute: Allied Metal Treating Corporation; Metal Treating, Inc.; Supreme Metal Treating Company; Thurner Heat Treating Company; and Wisconsin Steel Treating and Blasting Company have announced that they are beginning a planned school for their employees.

At first during the experimental stages, each participating company will send a maximum of seven employees each. The class will be held on Saturdays so as to enable the night crews to attend. The sessions will be of three hours' duration with two and one-half hours devoted to lectures and one-half hour to general questions and discussions. As the program progresses, more employees will be participating.

## MEMBER ACQUIRES NEW PLANT

Announcement was made recently that the New England Metallurgical Corporation, Boston, Massachusetts, a member of the MTI, will take over the plant formerly owned by the American Brake Shoe Company in Norwood and operate it as a division.

The New England Metallurgical Corp. of Boston has two divisions, one in Springfield, and the other in Worcester, as well as the main plant in South Boston. The Norwood property will be operated as a separate division.

The New England Metallurgical Corp. specializes in metals processing including the heat treating of steel, aluminum and other alloys as well as all of the methods of metal joining such as Hydrogen Brazing, Silver Soldering, Bright Hardening of stainless steel and so forth.

The equipment division, along with the special departments, will be operated at Norwood, and the other branch plants will continue to operate as they have in the past.

Dudley Bach has been president of the company since 1925 when it was first started in South Boston, and has seen it grow from three men to the present three-plant operation which now employs over 175 people. He has been active in many national and community affairs among them a Past Director of Greater Boston Chamber of Commerce, past President of the Small Business Association in New England, Chairman of the Boston Chapter of the American Society for Metals as well as at present a member of the National Council of Consultants for the Small Business Administration.

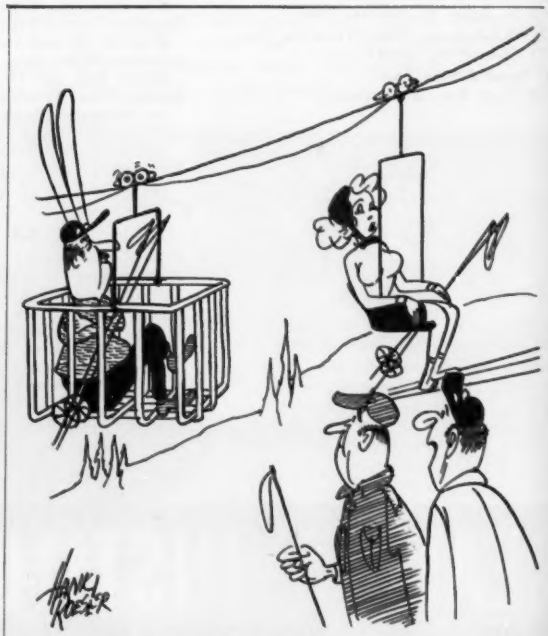
## THREE NEW MEMBERS

The following three companies have been admitted to membership in the Metal Treating Institute with the necessary aproval of the Board of Trustees and local members:

Lincoln Heat Treat, Inc.
21235 John R.
Hazel Park, Michigan
Mr. Lincoln Woodworth
—President

Pittsburgh Metal Processing Co., Inc.
1850 Chapman Street
Pittsburgh 15, Pennsylvania
Mr. John T. Howat
—President

Quality Steel Treating Company
1630 Locust Street
Anderson, Indiana
Mr. Lloyd R. Mattson
—Owner



"-SOME BIG WHEEL IN THE METAL TREATING INDUSTRY."

## NEWS TO HEAT TREATERS

(Continued from page 28)

resistance to corrosion and oxidation. The alloys are particularly useful for brazing austenitic stainless steel, high-nickel heat-resistant and precipitation-hardening alloys. They will also braze carbon steel and non-ferrous metals having melting points above 1850°F. Applications include joining high-temperature resistant parts for jet engines and rocket motors, honeycomb structures, heat exchangers, and corrosion-resistant equipment for food, dairy and chemical processes.

The four high-nickel alloys have nickel contents ranging from 72.5 to 93.25 percent, silicon between 3.50 and 5.00 percent, and boron between 1.90 and 3.50 percent. All are available as cast rod, powder, resin-bonded sheet, as well as in forms fabricated and sintered from the powder.

The alloys are self-fluxing when

(Continued on page 40)

# HEAT TREATING MECHANIZATION

## IS A FAMILIAR STORY TO AJAX!

■ In hundreds of applications, complete heat treating cycles are handled automatically by conveyorized salt bath installations engineered from beginning to end by Ajax.

From small parts to big ones; whether difficult shapes or selective heating requirements, the work is done faster . . . at less cost . . . in less floor space . . . with exceptionally uniform results.

From single furnaces to elaborate combinations, each operation is automatically operated and controlled, and the human element eliminated.

Exceptionally broad experience with merry-go-round, jackrabbit, screw conveyor, rotary basket, swing, elevator, push-pull and other heat treating mechanisms gives Ajax a head start on solving your mechanization problem the minute you bring it to us.

Send details of your proposed installation for recommendation.

AJAX HUGTGREN electric SALT BATH furnaces

**AJAX ELECTRIC COMPANY**

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In the ALUMICOAT Process, heat treating fixtures, trays, etc, are dipped in molten aluminum to produce a metallurgical iron-aluminum bond at the interface and a surface overlay of pure aluminum. At temperatures exceeding the melting point of aluminum, the aluminum on the surface diffuses. This diffused coating, together with the iron-aluminum bond, provides a refractory material that gives steel maximum protection against high temperature scaling.

The ALUMICOAT Process can give you greater economies through the use of lighter yet more rugged fixtures with a longer life through added resistance to corrosion and heat oxidation!

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ARTHUR TICKLE ENGINEERING WORKS, INC.

19 Delevan Street MAin 5-4200 Brooklyn, N. Y.

## HEAT TREATMENT OF TITANIUM

(*Continued from page 31*)

There is no known method for curing this "beta embrittlement". In order to prevent its occurrence, as much hot reduction (forging, extrusion, rolling) as possible should be done in the alpha-beta temperature range. All finish reductions should be in this range. A partial remedy for beta-embrittled parts is a restorative heat treatment. This is one which generally produces minimum permissible strength, but which does improve ductility. Examples are furnace cooling from the alpha-beta range or holding for prolonged periods in the vicinity of 1100°F, as is depicted in Fig. 6.

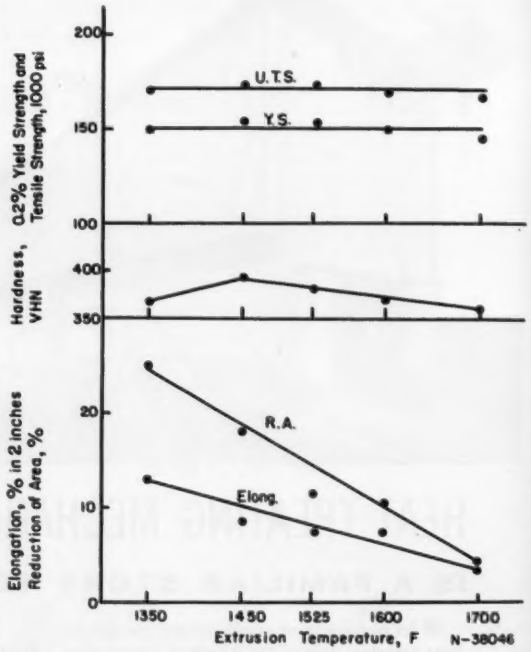



Fig. 10—Effect of extrusion temperature on properties of solution treated and aged Ti-3Mn-complex alloy. Bars quenched from 1300°F. and aged 8 hours at 900°F. (13)

### *Preventing Contamination and Distortion During Heat Treatment*

The problems of air contamination during heating and distortion during quenching have caused difficulty in the past and will be even more serious as heat treatments are used more frequently. At the present time there is no fool-proof method for avoiding oxidation in titanium parts exposed to temperatures much above 1100°F except by heating in vacuum, and this is not practical in most instances. Some forging companies have used nickel plating to achieve protection. This is only partly satisfactory since the parts must be replated after each forging reduction. The application of nickel plating to large parts, such as sheets, is not practicable.

(*Continued on page 50*)

# LETTERS TO THE EDITOR

Dear Editor:

We are interested in your magazine as a source of information for our heat treaters. What is the cost of a subscription?

*GLENN E. STOVER*
*Machine Shop Manager*
*Dresser Manufacturing Division*
*Dresser Industries, Inc.*
*Bradford, Pennsylvania*

Dear Editor:

Our library is in need of a copy of the following article: Ogilvie, R. E., "Applications of X-rays to heat treating industry", METAL TREATING., v. 7, No. 1, Jan.-Feb., 1956:25.

It will be appreciated if a copy of the above article can be forwarded. It not available, please forward the author's address.

Thank you for your cooperation in this matter.

*(MRS.) ANNE S. DICKENS*
*Librarian-Research and Development Department*
*Pitney-Bowes, Inc.*
*Stamford, Connecticut*

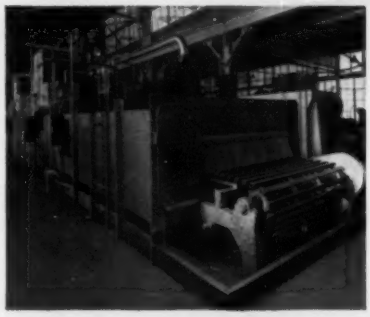
Dear Editor:

We would appreciate your sending us six additional reprints of Mr. V. H. Erickson's article on "Isothermal Heat Treating."

We thought this was a very fine article and we intend to send a few copies to some of our customers whom we believe have difficulty in understanding what we mean when we refer to the various methods of heat treatment. The article is both concise and yet very clearly describes the various methods. Thank you very much.

*H. ALMDALE*
*Almco Steel Products Corporation*
*Bluffton, Indiana*


# Continuous CIRC-AIR Tempering AT ± 5° F.

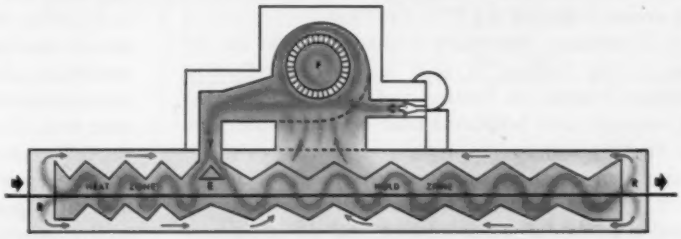


Industrial's "Circ-Air" tempering furnace is the most efficient heating machine ever designed.

The turbulent recirculation of hot gases through and around the work insures maximum and uniform heat transfer. Proper channeling of the hot gases to the work prevents wasteful dissipation of heat; and puts heat where it is needed — on the work.

A "Circ-Air" processing 2000 lbs. per hour at 1300° F., holding ±5° F., forces 14,500 C. F. M. of hot gases through the work. "Circ-Air" heating is recirculation at its best.

The continuous "Circ-Air" is suitable for heating steel, brass, aluminum and cast iron at temperatures up to 1450° F.



**WHY THE CIRC-AIR IS THE BEST TEMPERING FURNACE!**

The work is carried on a continuous conveyor. Loading can vary; ¼" bolts are densely loaded up to 3" deep. Less dense loading may be 20" deep. A 3' x 21' "Circ-Air" tempers over 2000 lbs. per hour.

Hot gases from the combustion chamber "C" and recirculated gases returning from the work chamber mix in the fan area "F." Entering the heating area through "T" at control temperature, balanced heat is directed to the charge and discharge ends, and is returned to the mixing chamber. The continuous V construction of the metal liner forces the hot gases up and down through the load at high velocity. The hot gases in the heating zone flow counter to the work. Heat transfer is rapid. Equilibrium is reached at point "E", and ±5° F. is held the length of the holding zone. Heating is without temperature head.

"Circ-Air" furnaces have been built in widths up to 108 inches, in lengths up to 165 feet, for temperatures from 250 to 1450° F., and capacities from 200 to 16,000 lbs. per hour. *Send for Bulletin 13-A*

CIRC-AIR

**INDUSTRIAL HEATING EQUIPMENT CO.**

3570 FREMONT PLACE, DETROIT 7, MICHIGAN • WALNUT 3-7000

PIONEERS AND STILL LEADERS IN RECIRCULATION

(*Continued from page 29*)

With a minimum of space and with no possibility of expansion, it may be necessary to compromise by using a smaller, all-purpose unit selected to do the major part of the work satisfactorily. Three-shift operation could be a requirement to meet the desired production on this basis. Electric heating would be indicated as the furnaces so heated are usually smaller for equivalent work space.

If the equipment is to be located in a production line in an area with relatively low head room, it is important to select units which are quiet operating and easy to keep clean. If a shaker hearth type of hardening furnace for small parts is required, it should be of the type using air actuating against the cushion of the cylinder. Such a furnace would properly be electric since there are no hot products of combustion which would require a suitable ventilating system. This advantage would be nullified in large part if the equipment were provided with atmospheres, the discharge of which does require some ventilation. The new Induct-O-Ring Furnace with the circular muffle heated by induction meets all these requirements and is a most compact machine tool. Heating that unit by induction eliminates hot element terminal connections too.

It is fortunate that space limitations affect the design of the furnace in only a few cases. Cooling chamber lengths on brazing and annealing furnaces on occasion have been shortened beyond a safe limit for bright work, but the space was at more of a premium than the slight bluing that resulted on the finished product. Usually, however, the room is provided after the furnace is selected, and the equipment is designed to do the best possible job with a judicious use of space.

### *Should the Furnace Be Fuel Fired or Electric?*

A final major consideration is the heating medium to use. Actual comparative cost per BTU or even per available BTU should not be the only factor in determining the means of heating. It must be remembered that in fuel firing a furnace, stack losses must be considered which increase greatly as the operating temperature increases. Radiation losses for similar construction regardless of the heating means, remain about the same. Thus, in the high temperature ranges, the cost of gas or oil would have to be much less than the cost of electric power per BTU to be comparable in cost of available heat. For this reason, a great many of the furnaces operating above 2000°F are electrically heated. Of course, the use of gas firing is justified economically in many high temperature operations because the extremely hot exhaust gases are used to preheat the incoming work. (See Table I on Stack Losses for Fuel Firing).

**TABLE I**

**Stack Losses for Fuel Firing**

| *Furnace Temp. °F* | *Stack Loss % Gross Input* | *% Gross Input Available Heat* |
|---|---|---|
| 400 | 84 | 16 |
| 600 | 79 | 21 |
| 800 | 74 | 26 |
| 1000 | 70 | 30 |
| 1200 | 65 | 35 |
| 1400 | 60 | 40 |
| 1600 | 55 | 45 |
| 1800 | 50 | 50 |
| 2000 | 44 | 56 |
| 2400 | 33 | 67 |
| 2800 | 20 | 80 |

**This table illustrates the available heat as a percentage of total input at various temperatures.**

Under any circumstance, the use of all heating means should be investigated. Electric heating has advantages because it is somewhat simpler to control, has no flue products to be vented, is clean, and lends itself nicely to the production of furnaces for use with atmosphere. It is now available for operations requiring high carbon potential atmospheres in direct contact with the heating elements such as are found in carburizing or carbonitriding operations. The Corrtherm low-voltage element reduces potential to a point that prevents shorting or grounding due to carbon formation. All types of furnaces are now available with this element. Electric furnaces are generally smaller in overall size which also adds to their appeal. In the temperature range above 2000°F, it is most difficult to provide fuel-fired furnaces for use with protective atmospheres because gas-tight muffles or radiant tubes are not available.

Fuel firing is applicable to most operations up to 2000°F and to some direct fired applications above that temperature. It is ideal in the tempering range because it is most economical, and in most areas of our country is probably less expensive for operations up to 2000°F. Radiant tube furnaces have been used for a number of years for all types of heat treating operations, and the recently introduced light weight, vertical, radiant tubes have simplified furnace construction and maintenance and reduced the physical size of the entire range of furnaces. Gas does have an advantage, too, in the flexibility of input that is provided due to the ease of varying the flow to the burner. It is ordinarily an easier task to provide high input and high heating rate in a fuel-fired furnace than an electric unit because the latter is limited to a given wall area for elements.

The use of oil is not as universal as gas and its chief use is in very large furnaces, direct heated for rough production work. For such applications, it is more economical since the heavier grades can be used. It is inclined to be dirtier than gas and it does

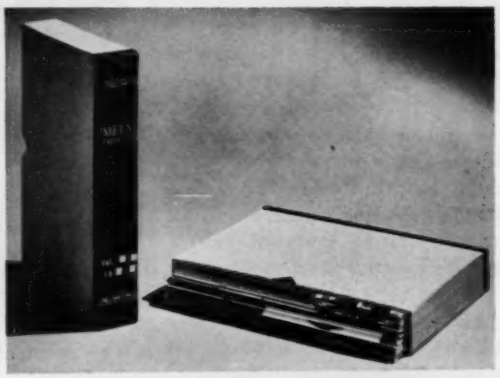
require larger combustion space. Because of its high BTU value, it is somewhat harder to control and this is particularly true in the smaller furnaces. It would be uncommon to find an industrial oil burner to handle less than 0.6 gallons of oil per hour at maximum turndown which is equivalent to 90,000 BTU per hour, whereas gas burners for any of the common fuels such as butane, propane, natural and manufactured gases are available down to 20,000 BTU per hour or less.

For these reasons, it can be seen that the heating means must not be selected solely on the basis of cost, but also on its merits for the particular job. It may be practical in many cases to provide additional power or gas capacity into the plant for a given job, although it may seem costly at the time.

No mention has been made of materials for construction of furnaces, and, of course, the use of high-grade alloy parts and refractory and insulating material in suitable quality and thickness is most important. Maintenance is a big factor in the cost of furnace operation, and it is good economy to pay a little more for top-grade materials which will give a long, trouble-free service life.

To make the most judicious selection of furnace equipment, it is necessary then to make a complete list of all factors to affect the decision. List the types of material, sizes, weights, treatment required, production, special handling, space available and heating media so that none will be overlooked. Then, investigate all of the possible arrangements in each case including many more than could be touched upon here. In the final analysis, you will find a clean-cut path to one or two types which will best fit your requirements.

■ ■ ■

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**DAFFY DEF**

*Hardening*: A primitive process by which steel parts are twisted into interesting shapes or artistic designs colloquially known as "cracks."

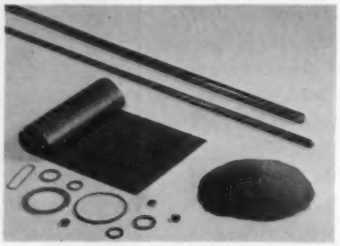
Sound Familiar?
PINCHER P. PENNY, SMALL PARTS MAKER, DECIDES TO DO HIS OWN HEAT TREATING.
THIS SENDING PARTS OUT FOR TREATMENT IS GOING TO STOP! WE'RE PUTTING IN OUR OWN DEPARTMENT!-SAVE MONEY, MAKE A BIGGER PROFIT...
BUT COSTS RUN HIGH AND NOW HE'S BLEATING!
SIX MONTHS LATER...
SEE, MR. PENNY. COSTS ARE UP, PROFITS DOWN! WE HAVE TO AMORTIZE EXPENSIVE EQUIPMENT, KEEP FURNACE TEMPERATURES UP ALL WEEK FOR THREE DAYS WORK... LOSS OF NEEDED FLOOR SPACE... MORE INSURANCE... BIGGER PAYROLL.
OK, OK! I GIVE UP!
SMALL PARTS TO LET OUT FOR HEAT TREATMENT
METAL TREATING EQUIP. FOR SALE
HANK

## NEWS TO HEAT TREATERS

*(Continued from page 35)*

used in a controlled atmosphere of dry hydrogen (dewpoint of –60°F or better), argon or helium. They can also be brazed in atmospheres of exothermic or endothermic gases and in air with the addition of flux. Standard brazing furnaces and salt baths operating at about 2150°F may be used for brazing. Cleaning and brazing procedures are generally similar to those for silver filler metals.

Properly designed joints may have tensile strengths of 75,000 to 95,000 psi depending on the atmosphere used, joint clearance and the composition of the brazing alloy.



The mechanical properties, corrosion resistance and oxidation resistance of these alloys closely approximate those of stainless steel and heat resistant alloys.

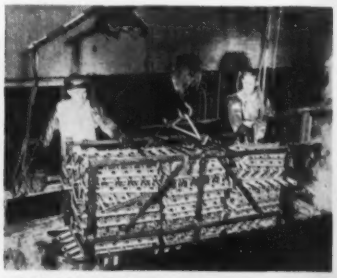
***For further information circle No. 8***

HEAT AND CORROSION RESISTANT
CASTINGS & FABRICATIONS
RADIANT TUBE ASSEMBLY
This General Alloys Company design combines castings and fabrications to obtain the best features of each for optimum performance and service life. The fabricated straight sections are light in weight and provide for maximum efficiency of heat transfer. The cast return bends offer maximum resistance to gas erosion and eliminates the welded area susceptible to early failure resulting from flame impingement. These tubes are available in many shapes and sizes. Let our engineering staff help you solve your heat resisting alloy problems.
GENERAL ALLOYS COMPANY
FABRICATED ALLOY DIVISION
403 WEST FIRST STREET • BOSTON 27, MASSACHUSETTS


## STAINLESS PICKLING RACKS

A specialty grade of stainless steel is said to have exhibited three to four times the service life so far of a copper-silicon-manganese alloy when exposed to 5–15% sulphuric acid at temperatures up to 200°F.

The specialty steel, known as Carpenter Stainless No. 20, is still being used by the Pennsylvania Plant of Line Material Co., East Stroudsburg, Pa., for this pickling rack and hangers shown here. These support 1,000-to-2,000-lb. loads of pole line hardware during pickling and galvanizing.



The stainless rack, a welded framework measuring 6 ft. long x 2 ft. wide x 30 in. high, was installed six years ago. The stainless hangers were installed eight years ago. All of these stainless parts remain in use today with every indication that they will render many more years of safe and dependable service.

Result of the switch to Stainless No. 20, an analysis developed in wrought form by The Carpenter Steel Company, Reading, Pa., has been maximum safety to employees working at the open acid tank–lower maintenance costs–and uninterrupted production.

Carpenter Stainless No. 20 is a sulphuric acid resisting steel with a type analysis of carbon–0.07% max., manganese–0.75, silicon–1.00, chromium–20.00, nickel–29.00, molybdenum–2.00 min. copper–2.00 min.

The nickel content, fortified with high chromium and molybdenum,

*(Continued on page 42)*

# THE ONE BEST WAY TO SELECT HEAT TREATING EQUIPMENT

***Talk it over with the most experienced furnace experts you can find***

That is exactly what we can offer you at Lindberg. A design and engineering staff concerned only with the development of equipment for applying heat to industry. This staff produces the most complete line of such equipment in the industry—heat treating furnaces, melting furnaces, ceramic kilns, high frequency induction units; big ones, small ones, electric or fuel-fired, built in our own plant or field-erected.

Whatever your requirements Lindberg's staff will study them without prejudice recommending the correct equipment to fill them whether you need only a simple heat treating furnace or a specially designed and developed installation to answer an exceptional problem in a newly-efficient way. You can be sure you have the right answer when you leave it to Lindberg. Get in touch with your nearest Lindberg Field Representative. (See your classified telephone directory or write us direct.)

This Lindberg Carbonitriding and Carburizing Furnace (electric or fuel-fired) is one of the most widely-used heat treating units in the world.

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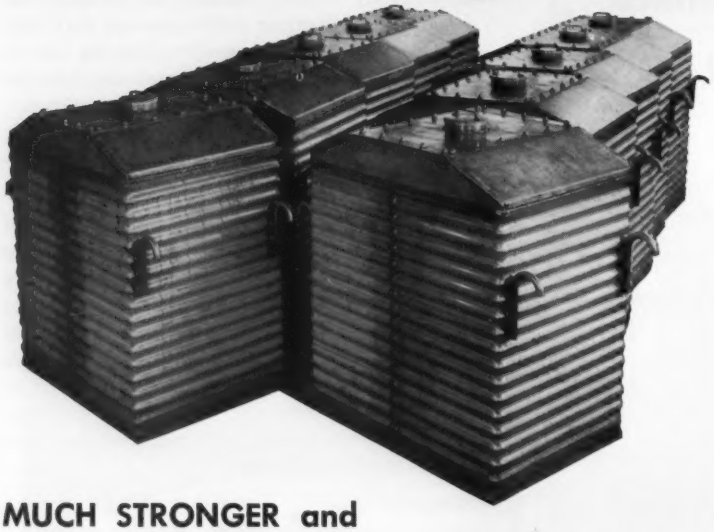
## FABRICATED ALLOYS
HEAT AND CORROSION RESISTANT



**MUCH STRONGER and**
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# CORRUGATED
## WELDED CONSTRUCTION

All the advantages of lighter weight, rapid heat transfer, easier handling and lower over-all cost are inherent in this Rolock-perfected construction technique. Yet there is no sacrifice of strength or anticipated performance. In fact, vessels such as those shown above, of Type 316 Stainless Steel, can be expected to out-perform alternative designs in every way.

Skilled Rolock craftsmen, using specially developed equipment and technique, form the corrugated construction WITHOUT welding at the corners — a very important feature.

This is another example of the way in which Rolock designing and welded fabrication skills can help you meet new or unusual equipment needs. Always consult us first.

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**JOB-ENGINEERED** for better work
Easier Operation, Lower Cost

SRLS7


## NEWS TO HEAT TREATERS

*(Continued from page 40)*

provides a suitable matrix to place the copper in solid solution. This is most important in securing unusually good resistance to sulphuric acid.

***For further information circle No. 9***

### SALT BATH FURNACE

A new salt bath furnace design which permits the replacement of submerged type electrodes without costly furnace shutdowns has been announced by Ajax Electric Company, Philadelphia, Pa. The removable type submerged electrodes can be changed in an hour, even before the molten salt has solidified. The sturdy electrodes are fabricated of non-critical alloys and enter the pot from over the top instead of through the back wall of the casing. Hence, there are no openings below the surface of the salt. An easily removable tile over each pair of electrodes seals off all air. This prevents the oxidation attack on the electrodes that normally takes place at the air-salt interface and assures much longer electrode life.

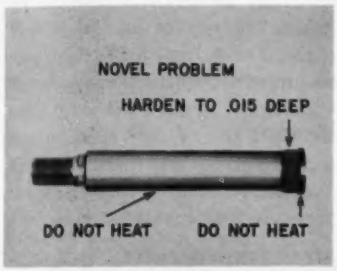
***For further information circle No. 10***

### INDUCTION HEATERS

The Radio Frequency Company of Medfield, Massachusetts, announces a new method of ultra fast induction hardening made possible with their line of induction heaters incorporating powdered core output transformers.

A specific application of these ultra fast induction heaters is the spring-shackle bolt shown in the photo. The problem here was to harden the knurl to a depth of approximately 0.012" without hard-

ening or even heating the head of the shank adjacent to the knurl or the shank under the knurl. The pin itself is driven into a hardened spring and the knurl must be hard to penetrate and hold. The head, however, must be soft to take the blow of pounding, otherwise it will shatter.




The problem, therefore, was to develop a completely new type of induction heater that would provide ultra fast heating. Ordinary induction heating techniques could provide a minimum heating time of 1 second with a 20KW unit. This time length allowed the shank to be heated, and the only solution to this was the spraying with a stream of water. By using the new type of ultra fast induction heater, this same operation is accomplished in 1/10 of a second on a 10 KW machine (at approximately ½ the equipment cost). Because it is accomplished so rapidly, no quenching is required. The residual cold of the pin does the quenching. The head remains completely soft and is not even discolored by the heat. The knurl is the only portion that is heated and hardened. The main body of the pin and the inside of the pin under the knurl remain soft and cold.

With the new heaters, all the operator is required to do is to push the pin into the coil where it automatically turns on the machine for the interval that was subsequently lengthened to ¼ of a second, and remove it. The theoretical output is approximately 10,000 units per hour. In actual practice, 3500 units per hour have been processed without difficulty, at a labor savings of 75% over other methods.

***For further information circle No. 11***


# GIVE METALS A COLD TREAT

with this NEW low cost **Cincinnati Sub-Zero** Mechanical Chilling Machine

Model A-120-2

STABILIZE ALLOY STEEL by complete change of austenite to martensite.

TOUGHEN METALS, increase hardness and life of perishable tools up to 400%.

STRESS-RELIEVE CASTINGS of magnesium, aluminum and cast iron . . . with SUB-ZERO Chilling!

- **Capacity: 400 BTU's per hr. at—120° F.**
- **2 cubic foot chamber**
- **All steel construction**
- **Hermetically sealed refrigeration system**
- **Easy "plug-in" installation**
- **Heating unit, observation window, other accessories available.**

**Standard or Special models provide Maximum Capacity in Minimum Size**

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**For large or small scale Production Chilling**

*There is a complete range of models, sizes and special designs to suit your job requirements. Write today for Catalog on the full line.*

**CINCINNATI SUB-ZERO PRODUCTS**

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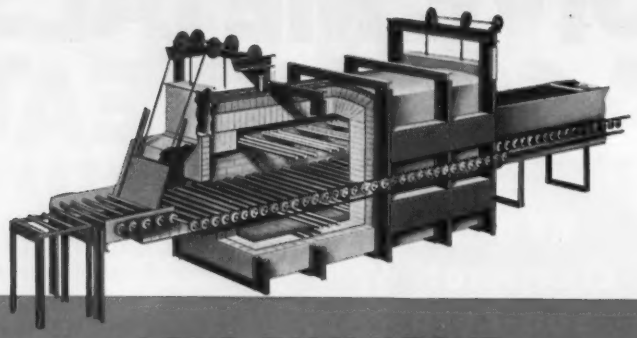
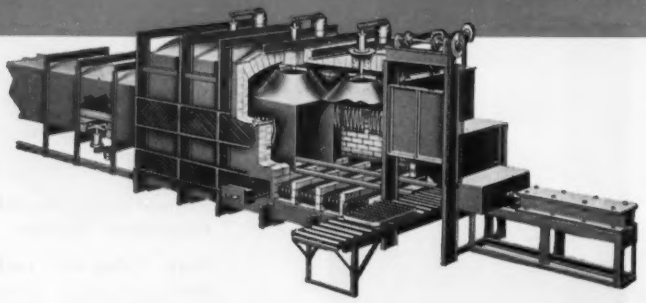
**3930F7 Reading Road** **Cincinnati 29, Ohio**

BLAZING THE HEAT TREAT TRAIL WITH HOLCROFT



LET'S TALK ABOUT

the economy of electric heating



Low initial cost—simplified maintenance—efficient use of heat.

All these represent good reasons why electric heat treat furnaces are important considerations. For example, gas-fired and electrically-heated furnaces are frequently competitive; in fact, when total installation cost figures are considered, electric furnaces often have the price advantage.

Upkeep is reasonable, too, because properly designed and installed electric heating elements are so easy to maintain and adjust. Elements are quickly removed for repairs.

Electric heat is more efficiently used for applications in the high temperature range. There is a considerably smaller heat loss in the use of electricity than gas—shrinking the price spread between the two. To be specific, a thorough study must be made of all factors: local power and fuel costs, production demands, quality control standards, etc., before any final decision can be made of the type of heating to be used. Holcroft will help you—a good place to start is to send for our new book **Holcroft and the Electric Furnace.** It's yours without obligation.

**HOLCROFT AND COMPANY**

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PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

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CANADA: Walker Metal Products, Ltd., Windsor, Ontario

## NITRIDED TOOLS

TEMCO Aircraft Corporation, Dallas, Texas, claims to be securing 200% to 400% longer life from end mills and other high speed steel tools as a result of salt bath nitriding. The nitrided case is .001 inches and is so hard that it cannot be measured by ordinary hardness tests, but must be measured by Vickers readings or a scratch test. In terms of Brinell hardness, readings up to 1100 Brinell are secured.

Tools are nitrided for one hour at 1050°F in an internally-heated electrode type salt bath furnace manufactured by Ajax Electric Company, Philadelphia, Pa.

Although there are some applications where nitriding is not warranted, in most instances nitriding can be used successfully to increase tool life, particularly tools made from steels alloyed with aluminum, chromium, tungsten, vanadium, titanium, or molybdenum.

***For further information circle No. 12***

MORE PARTS PER HOUR with General

FLEXIBLE-POWER STRAIGHTENING PRESSES

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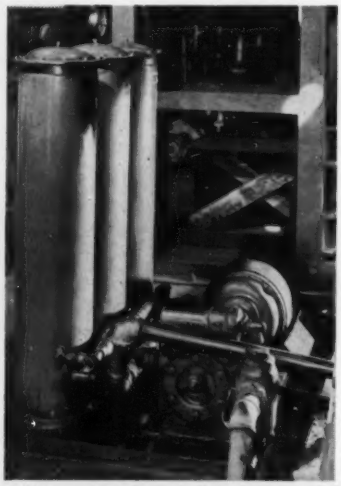
## OIL PURIFYING UNIT

The unit manufactured by Mayhew Products Company, Los Angeles, California, claims to keep heat treating oils clean. These oils contain a certain percentage of soluble waxes, gums, and varnishes, which upon contact with hot metals become a moving non-soluble material and pick up fine metal particles, dirt, lint, and scale. When cooled within the heat exchanger tubes, this dirt is deposited on the tube walls and eventually stops oil flow. The dirt is also deposited on the part being treated and attracts carbon, dirt, and metal particles in the oil, preventing further treatment until equipment is cleaned.



When this non-soluble material is filtered with Mayhew's purifying unit, a finished pure oil is left which is said to be usable indefinitely. The size of the unit is based on the quantity of oil in service.

***For further information circle No. 13***

*(Continued on page 58)*


**WANTED**

1—Continuous atmosphere hardening furnace (shaker hearth or alloy belt conveyor) in the vicinity of 400-800 lbs. per hour.

2—An endothermic generator and a continuous tempering furnace.

3—A homo steam draw furnace.

Box MT 300

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Start heat treating high speed and carbon steels while other furnaces warm up. Powerful burners in this efficient furnace get heat up to 1300°-2350° F. range in minutes. Temperatures accurately and quickly regulated. Ratchet-operated door opens upward — no need to open fully every time. High temperature refractory-lined firebox keeps heat uniform — 7" by 13" by 16½". 200,000 BTU's per hr. Carbofrax hearth, G.E. Motor and Johnson Blower included ..... F.O.B. Factory, $337.00

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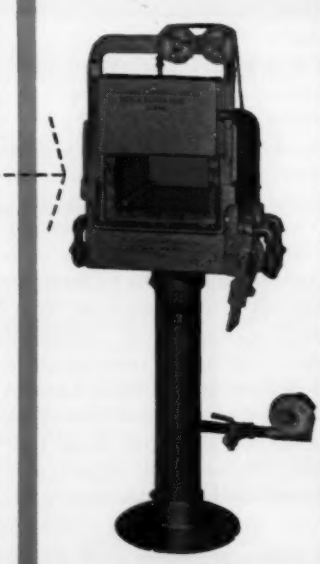

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# MANUFACTURERS' LITERATURE

*For your copy circle the number on the Readers' Service Card*

## HIGH ALLOY ASSEMBLIES

A new 4-page bulletin released by General Alloys Company, Fabricated Alloy Division, Boston, Massachusetts, describes and illustrates the company's specialized services for production of high alloy assemblies for the chemical, petroleum, heat treating, food, petrochemical, pharmaceutical, and other process industries. Large-scale production facilities include a modern welding set-up, a complete foundry, and chemical and metallurgical laboratories for research and analysis.

***For further information circle No. 14***

## SIMPLE ANALYSES FOR SOLUTIONS

"Simple Methods for Analyzing Plating Solutions" is a new 36-page, two-color bulletin now offered by Hanson-Van Winkle-Munning Co., Matawan, N. J.

The bulletin is prefaced by a discussion of analytical principles, use of apparatus and methods for sampling a plating solution. It then outlines in detail the necessary steps involved in 28 analytical methods for testing nickel, copper, silver and other metalfinishing solutions.

Other sections of the bulletin describe necessary equipment, component chemicals of solutions, atomic weights, acid concentrations and electrochemical data. Conversion tables are included. Analytical reagents are listed for brass, cadmium, chromic acid, copper cyanide and sulfate, gold, nickel, silver, tin and zinc plating solutions.

***For further information circle No. 15***

## LOW-ALLOYED STEELS

The relationships between microstructures formed with various cooling rates and austenitizing temperatures and properties at 700° to 1200° F. for three low-alloyed steels are analyzed in a 78-page report of research for the Air Force released to industry through the Office of Technical Services, U. S. Department of Commerce.

The three steels are Ni-Cr-Mo (SAE 4340), 1.25Cr-Mo-V ("17-22-A"S), and 3Cr-Mo-W-V (H-40). Martensite, martensitic - bainitic, bainitic, and bainitic-ferritic structures were produced by oil quenching 1-inch rounds and air cooling 1-inch and simulated 3- and 6-inch rounds.

PB 121149 *A Survey of the Effect of Austenitizing Temperature and Rate of Continuous Cooling on the Structure and 700° F. to 1200° F. Properties of Three Low-Alloyed Steels,* may be obtained directly from OTS, U. S. Department of Commerce, price $2.

## ALLOY SHEET METAL FABRICATION

Engineers and technical purchasing specialists looking for the unusual and complex in alloy sheet metal fabrication will find this book a helpful source of information. Published by S. Blickman, Inc., the book anticipates problems facing these engineers and buyers. It describes how special fabrication skills solved problems involving intricate shapes, close tolerances, special welding techniques, high finishes and mechanical components.

Alloys include stainless steel, aluminum, monel, inconel, nickel, titanium, multimet alloy, Hastelloy and other metals in gauges up to ⅜". Sizes vary from small assemblies to dimensions of 30' long or more. Numerous illustrations in the book show a wide variety of unusual equipment used in many different industries.

***For further information circle No. 16***

## THERMOCOUPLE DATA BOOK

A new 40-page bulletin discusses construction and application of thermocouples and radiation detectors as used on industrial control applications. Included is information on "How to Check Thermocouples", "How to Make Thermocouples", "How To Select and Size Thermocouples", plus other useful information for instrument men.

Included as a portion of the new Wheelco Data Book published by the Barber-Colman Company, Rockford, Ill., are standard thermocouple temperature?millivolt equivalents with temperatures being expressed on the International Temperature Scale of 1948. The electromotive force is expressed in absolute units.

***For further information circle No. 17***

## INDUSTRIAL FANS

A new line of industrial fans designed to handle corrosive and explosive fumes, high temperatures and humidity, abrasive dusts and dirt-laden air is featured in a bulletin compiled by the Propellair Division of Robbins & Myers, Inc., of Springfield, Ohio.

The six-page, two-color bulletin describes the applications for the belt-driven tubeaxial fans and the requirements for use under special conditions such as high temperatures, corrosive exhaust and outdoor installation.

Complete information on the construction features, accessories, bearing assemblies and performance of the five fan sizes, ranging from 16 to 36 inches, is included in the bulletin. The fans have air delivery ratings to 26,000 cubic feet a minute.

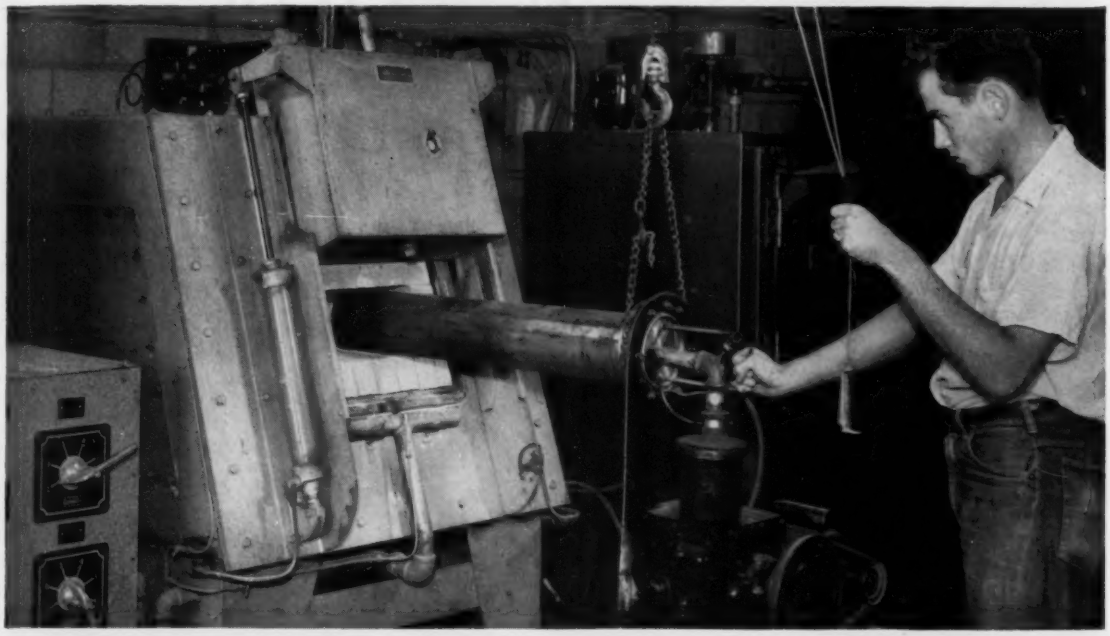
***For further information circle No. 18***

*(Continued on page 49)*

## *Electric furnace users and builders report:*

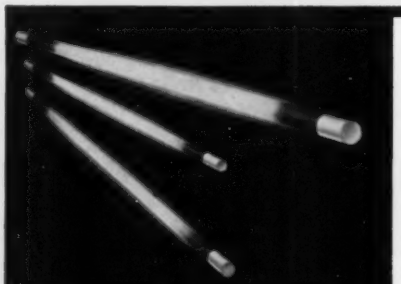
# "HOT RODS" PAY OFF!

### *Progressive firms list advantages of CRYSTOLON* heating elements*



**Metallurgical Consultants, Inc., of Los Angeles** say that "Hot Rods" provide excellent service life for a variety of heat treating applications including vacuum and protective atmosphere work. Their furnace, shown above, is used for heat treating a wide variety of parts. This requires several daily temperature variations, from 1600°F. to 2300°F., causing repeated thermal shocks to the heating elements. Yet the original "Hot Rods" — Norton heating elements — show no signs of failure after more than two years of this especially hard service.

The builders of this furnace, the Pacific Scientific Company of Los Angeles, Calif., are equally enthusiastic. They report that the long and better operating service of "Hot Rods" more than justifies their use in any electric furnace requiring nonmetallic heating elements. As a result, they install these Norton CRYSTOLON heating elements in every furnace of this type they build.



Many plants report that Norton heating elements outlast other nonmetallic elements *up to 3 to 1!* This much longer life means savings in element costs, because fewer elements are needed. Also, you get reduced maintenance, due to less changing of elements or voltage taps. And "Hot Rods" help protect product quality because their slow, evenly matched rate of resistance increase means more uniform heating.

The big, illustrated booklet, *Norton Heating Elements*, gives further facts on how "Hot Rods" can help improve your furnace operations and cut costs. Write for your copy to NORTON COMPANY, Refractories Division, 622 New Bond Street, Worcester 6, Massachusetts.

**Norton CRYSTOLON Heating Elements,** or "Hot Rods," are a typical Norton B — an expertly engineered refractory prescription for greater efficiency and economy in electric kiln and furnace operations. Made of self-bonded silicon carbide, each rod has a central hot zone and cold ends. Aluminum-sprayed tips and metal-impregnated ends minimize resistance and power loss. Available in standard sizes.

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*Making better products... to make your products better*

NORTON PRODUCTS:
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Grinding Machines • Refractories

BEHR-MANNING PRODUCTS:
Coated Abrasives • Sharpening Stones
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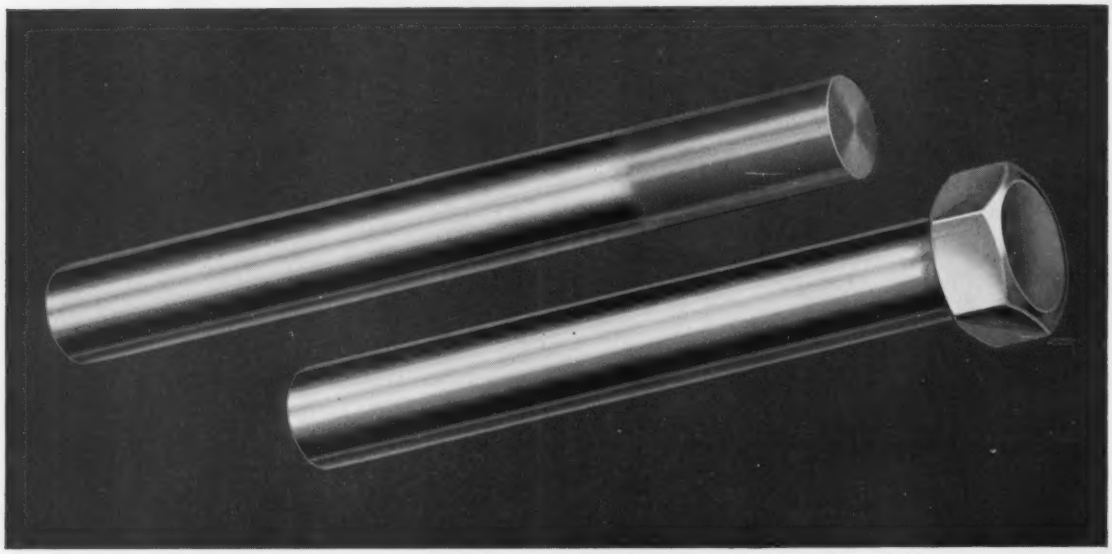
# Die Life Increased Up To 400%

## *with* TOCCO* *Induction Heating*



• Naval Bronze, Silicon Bronze, Copper, Aluminum, Monel and all types of stainless steel are heated for forging at the H. M. Harper Co., Morton Grove, Illinois. Regardless of material TOCCO can be profitably applied to brazing, heat-treating and forging operations in almost any metal-working plant.

**Production Up**—In addition to the very important savings in forging dies, TOCCO has increased production to as much as 265% of output possible with former heating methods. On the 1" type 303 Stainless machine bolt blanks shown here TOCCO upped production from 75 to 200 parts per hour, using 35 K. W., 10,000 cycles.

**Versatile**—The same TOCCO machine is used on stock of ⅜" to 1¼" diameter; heated zones vary from ½" to 4". TOCCO'S automatic timing cycles provide complete uniformity of heating throughout both length and cross section—assuring a uniformly high quality product.

Why not have a TOCCO Engineer investigate your plant to determine where TOCCO can cut your costs and streamline your production?

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## MANUFACTURERS' LITERATURE

*(Continued from page 46)*

### TITANIUM REPORT

The effects of various production elements on the properties of titanium and its alloys are described in a report of research for the Air Force released to industry through the Office of Technical Services, U.S. Department of Commerce. The report is briefly described here.

*Structural Changes of Commercial Titanium and Titanium-Base Alloys on Heat Treatment.* Armour Research Foundation for Wright Air Development Center, U.S. Air Force. May 1954. 123 pages. (Order PB 111767 from OTS, U.S. Department of Commerce, Washington 25, price $3.25.) Summary report of one year's research in a program to develop a fundamental understanding of the principles upon which the heat treatability of titanium-base alloys may be founded. A resistometric procedure for determination of transformation kinetics of transforming titanium alloys was developed and results of studies on selected alloys of the titanium-manganese and titanium-iron systems are presented. Tensile and impact properties and microstructures of three titanium-manganese alloys, heat treated according to schedules dictated by TTT curves established resistometrically and practical considerations, are given. The influence of dispersed carbides, presumably TIC, on grain growth characteristics and tensile properties of three titanium-molybdenum alloys is determined.

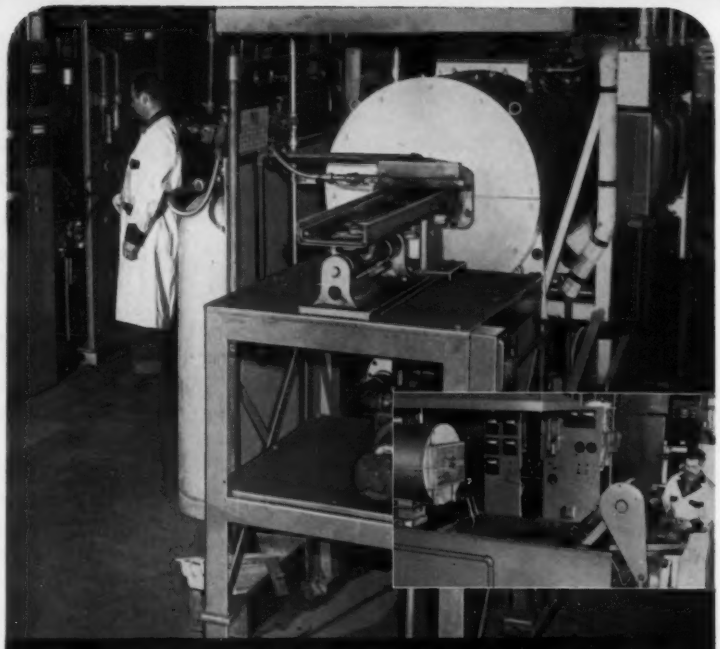
### FLOWMETER EQUIPMENT

The Selas Corporation of America, Dresher, Pennsylvania, has recently published a bulletin entitled "The New Series F Selas Flo-Scope."

Selas Flo-Scopes are used for measuring flow rates of air and gases, separately or in mixtures, for combustion in furnaces and ovens.

***For further information circle No. 19***

*(Continued on page 51)*

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Gage blocks, industry's standard of precision measurement require accuracies within millionths, hardness adequate to resist wear and freedom from distortion and warpage. DoALL Gage Blocks, distinguished throughout the world for excellence, are heat treated to meet rigid specifications. —

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- No Warpage
- No Scale
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The Hevi Duty Shaker Hearth Furnace treats to these specifications because—

The heating time cycle can be accurately set.

Zone temperature control regulates heating rate and maintains exact quenching temperature.

A prepared atmosphere and enclosed quench protect the blocks from scaling.

Each part receives individual yet uniform treatment on a mass production basis.

*Write for Bulletin HD-850 and more information how this modern furnace can solve your heat treating problems.*

HEVI DUTY ELECTRIC COMPANY

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*Heat Treating Furnaces... Electric Exclusively*

*Dry Type Transformers* *Constant Current Regulators*

## HEAT TREATMENT OF TITANIUM

(*Continued from page 36*)

Several companies have been active in the evaluation of paints and sprayed or dipped coatings for titanium. The Boeing Airplane Company has been experimenting with aluminum paint to avoid oxidation in large sheets of the Ti-6A1-4V alloy solution-treated at 1700°F. This type of protection has shown promise. Convair, San Diego, recently reported on the results of a number of coatings applied to commercially pure titanium. The Mollerizing process was found to show promise at exposure temperatures of 1400° and 1600°F. This process consists of dipping the sheet into a bath of flux and molten aluminum, the aluminum floating on top of the flux and being deposited as the sheet is drawn upward from the flux through the aluminum layer.

In the past, few, if any, attempts have been made to strengthen titanium parts by heat treatment after a forming operation. Stress relief treatments, carried out at low (1000°F) temperature on formed sheet, have required rather elaborate precautions, such as heating fixtures and cooling dies, to prevent distortion. It is hoped, of course, that the sheet alloys being developed will be formable in the quenched condition and will not require heating at high temperatures atfer forming. Even if this is possible, it will be necessary to prevent distortion during the solution treatment of the blanks to be formed. In the case of large sheets, distortion during quenching may pose serious difficulties.

Boeing has had success in solution treating and aging 36 x 96 inch sheets of the Ti-6A1-4V alloy at 1700°F with little distortion. This is done in air in a vertical pit furnace. The sheet is hung from a spider in such a way that there is both longitudinal and transverse tension in the sheet. After quenching, the sheet is aged between flat dies for 4 hours at 1000°F. This treatment is said to have produced very flat sheets.

A heat treating operation that may be adaptable to titanium is the "Slat-Quench" process developed by McDonnell Aircraft Corporation. This has been used with outstanding success for heat treating very large (18 x 6 feet) sheets of 7075 aluminum alloy, with minimum distortion, for subsequent stretch forming in the quenched condition. Sheets are suspended from a spider during the heating operation, which is done in a salt bath. After heating, the sheet is removed, in a matter of seconds, into the quenching tank. The tank, approximately 25 feet long by 15 feet deep, consists of a dry center compartment and two water compartments. The compartments are separated by metal slats which are closed while the sheet is lowered into place in the dry center compartment. The slats are then opened and water from the adjoining compartments strikes the sheet from both sides at the same

(*Continued on page 54*)

**Pangborn Hydro-Finish cut cleaning time 50% in this plant**

**Paid for itself in only six months**

Pangborn Hydro-Finish really paid off for this leading glass manufacturer. Cleaning quality increased moldlife 10% to 15% and total cleaning and polishing time was cut in half! The resultant savings paid for the machine in six months and represented a substantial weekly sum thereafter.

**USE PANGBORN HYDRO-FINISH FOR:**

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Today, through new design and use of air jet sluriators, Pangborn Hydro-Finish costs less originally, costs less to maintain and gives you easier handling and added efficiency. Write for Bulletin 1403 to PANGBORN CORP., 3600 Pangborn Blvd., Hagerstown, Md.

**Pangborn**

**BLAST CLEANS CHEAPER**

## MANUFACTURERS' LITERATURE

*(Continued from page 49)*

### AIR-OPERATED HARDNESS TESTER

Brinell hardness testers have undergone changes as witnessed by the new air-operated, semi-automatic Air-O-Brinel introduced by Tinius Olsen Testing Machine Company, Willow Grove, Pa.

Positive application of standard Brinell loads of 500, 1000, 1500, 2000 and 3000 kg. is said to be assured because the accurate gauge mounted at the top of machine shows exactly what load will be applied *before* the test is made. To use the Air-O-Brinell, the operator simply adjusts the air pressure regulator valve until the desired Brinell load is indicated on the gauge. Once the load is set, any number of hardness tests can be made in rapid sequence. Load is applied by pulling out the plunger-type control valve and released instantly by pushing it in.

The machine need only be attached to a standard compressed air supply. Fluctuations in air supply pressure above 65 psi will not affect accuracy of the machine.

***For further information circle No. 20***

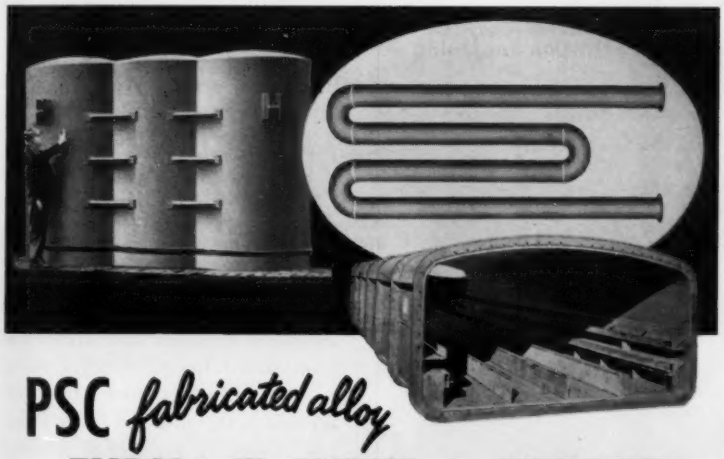
### CRUCIBLE CATALOG

A new, 232-page product and warehouse catalog has recently been published by Crucible Steel Company of America, Pittsburgh, Pa.

The well-illustrated and indexed book is designed to show the reader the complete range of grades and sizes available from stock of Crucible's special steels—high speed, tool, stainless, alloy, machinery and special purpose steels.

Data sheets showing the application, suggested heat treatment and metallurgical information are also available for most grades of Crucible steel.

***For further information circle No. 21***

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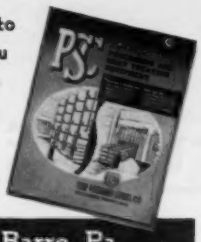
*Send for PSC Heat-Treat Catalog 54*



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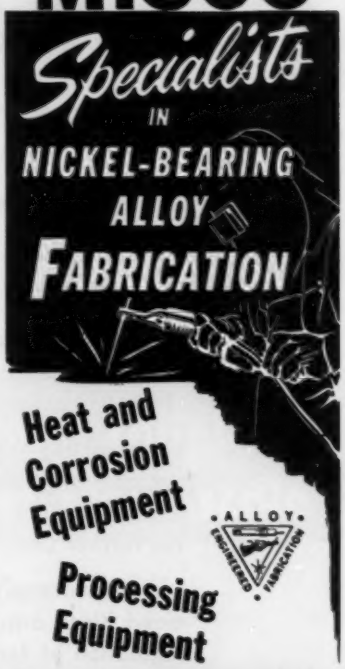

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HEAT-RESISTING ALLOY
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***"The Sentry Diamond Block Atmosphere Makes the Difference"***

Grobet File Co. of America, Inc., Carlstadt, N. J., has eliminated spoilage in the hardening of its fine quality high speed rotary files by use of Sentry equipment.

Sharp cutting edges formed by impact on chisel cut files are protected by the Sentry Diamond Block Atmosphere through the hardening cycle. No further sharpening is required.

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TRADEMARK

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### DUST CONTROL BULLETIN

"Dust Control for Industry" is the title of a new 16-page illustrated reference bulletin released by the Pangborn Corporation, Hagerstown, Md., for plant engineers, managers and maintenance engineers in the process industries.

Encompassing the complete range of dust control equipment and accessories, the new bulletin describes the importance of dust control to industry in relation to reduced maintenance costs, employee morale, and commercial utilization of dust by-products.

***For further information circle No. 22***

### POTENTIOMETER PYROMETER

An 8-page bulletin describing the improved Pyrotest, said to be the only portable potentiometer pyrometer with interchangeable direct-reading scales, has been published by Technique Associates, Indianapolis, Ind.

The improved Pyrotest checks and calibrates all types of thermocouple-actuated temperature instruments, and many electrical instruments. Temperatures or millivolts are read directly—without charts, graphs or conversion tables.

***For further information circle No. 23***

### STANDARD DESIGNATIONS FOR CASTINGS

The latest revision of the list of standard designations and chemical composition ranges for heat and corrosion resistant cast alloys has been issued by the Alloy Casting Institute, Mineola, New York. Of interest is the addition of two new cast alloys of the "18-8" variety, with very low carbon contents. Used in some service as alternates to the columbium-stabilized grade, or for especially severe corrosive conditions, these alloys bear the designations CF and CF-4M. Nominally, these grades correspond to the wrought types 304L and 316L, respectively.

In addition, the free-machining grade CF-16Fa has been reinstated to the ACI standard designation

list. Containing molybdenum and sulfur, this grade provides an alternate to the selenium-containing type CF-16F cast high alloy.

***For further information circle No. 24***

### BARREL-FINISHING

"Barrel-Finishing with Norton Tumblex Abrasives" is the title of a completely revised 76-page booklet being offered by Norton Company of Worcester 6, Massachusetts. The booklet includes information on types of barrels, selection of abrasive, cleaners, time cycles, and other important facts about barrel-finishing.

***For further information circle No. 25***

### PORTABLE TEMPERATURE INDICATORS

Complete information about L&N's portable, direct-reading thermocouple potentiometer indicators with automatic reference junction compensation is now available in a new Data Sheet published by Leeds & Northrup Company, Philadelphia, Pa.

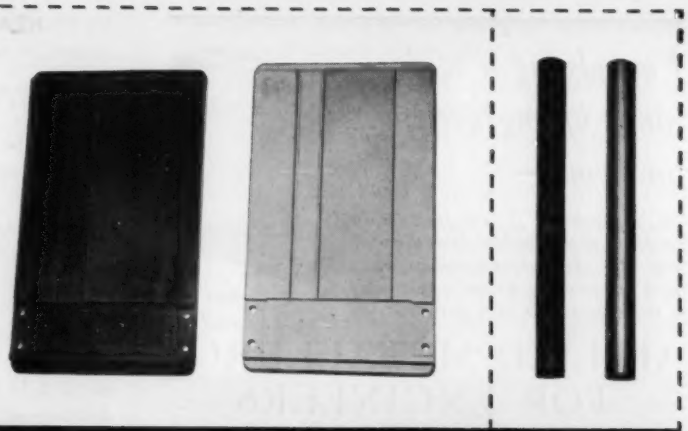
***For further information circle No. 26***

### CLEANING COMPOUNDS

An 8-page bulletin describes the complete line of industrial cleaning compounds and solvents of the Brulin & Co. Inc., Indianapolis, Ind. Illustrated with photographs, this bulletin gives detailed information and applications of chemicals for every industrial cleaning requirement. Ranging through the various cleaners and degreaser are the following:

Brulin's liquid Steam Charge for light and medium-duty steam cleaning where speed and safety are required; Brulinsolv, an emulsifiable liquid concentrate for cleaning and degreasing all metal and concrete surfaces; Brulin's Rust & Scale Solvent for cleaning rust, scale and corrosion from aluminum, stainless steel and most other metals; and Brulin's Lume-Brite, a specialized liquid cleaner designed to solve the most difficult cleaning of corrosion, pit marks and oxidation from aluminum.

***For further information circle No. 27***

STEELETTS® clean toughest heat treat scale

**cut abrasive consumption 73.8%**

AT COMMERCIAL STEEL TREATING COMPANY

Steeletts, the heat treated electric furnace steel grit, reduce abrasive consumption and maintenance costs while cleaning even the toughest heat treat scale at Commercial Steel Treating Corp. One of the largest job heat treat companies in the United States, this Detroit firm changed to Steeletts only after exhaustive tests.

Mr. Anthony J. Beck, Plant Engineer, points out the first consideration of a job plant must be finish, because customers demand thorough cleaning and uniformity of finish from batch to batch. Steeletts scored high on this count and gave improved speed, too. But in addition to these advantages, Steeletts outlasted chilled iron 4 to 1 in tests conducted in the same blast cleaning machine on the same type of work. Grit consumption was cut 73.8%, and Mr. Beck pointed out, "We find that when a grit has a longer life, equipment maintenance savings are greater than the savings we make in grit costs."

Investigate the savings you can make in grit costs and maintenance costs by using Steeletts. Write today for Bulletin No. 901-D.

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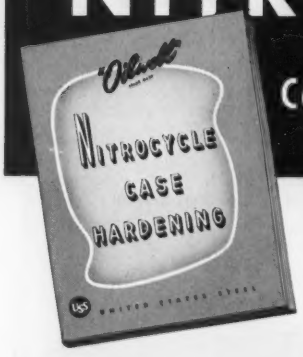


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## HEAT TREATMENT OF TITANIUM

(*Continued from page 50*)

instant, producing a uniform quench over the entire surface.

It will be apparent from this article that, although much is now known of the principles of titanium heat treatment, many practical problems remain to be solved. Relatively little information exists, as yet, on the properties of commercial alloys after heat treatment. Depth of hardening data, thermal stability data, information on the effects of impurity elements at the high strength levels made possible by heat treatment, all have to be obtained and evaluated. The optimum methods of heating for specific applications have to be determined. For example, improved methods for protecting titanium during heating have to be developed. This will involve studies not only on chemical protection but also on heating methods and furnace design. These are serious problems. However, the future that these newly developed heat treatments have opened for titanium alloys certainly justifies the application of considerable time and expense to overcome these problems. ■■■

## HOT OIL QUENCHING

(*Continued from page 12*)

Fig. 7 illustrates how an efficient quench tank is designed. Note the controlled and uniform flow of oil in this system. Two impellars at the bottom assure adequate agitation.

### *Heating Arrangements*

Production can be either batch or continuous for hot oil quenching. Another important feature of the quench equipment is the heating or temperature control of the oil during and after the quench cycle. Radiant tube heating with an adequate surface area for heat transfer to the oil assures minimum temperature differential and rapid heat transfer without excessive coking or decomposition of the oil. Another function of the radiant tube system is cooling the oil after quenching. Air is pulled through the system by means of an exhauster, and this provides sufficient cooling even though the interval between quenches may be relatively short on some types of heat treating operations.

As to the final selection of heating arrangements it can be seen that the determining factors will include whether the operation is batch type or continuous, and whether full marquenching or modified marquenching is adopted.

### *Field Performance*

The data cited in the following briefs are intended to show the actual results obtainable commercially either by full marquenching or the modified marquenching process.

The first example shows how full marquenching with an oil at 350°F. has effectively replaced a conventional or cold oil operation of 130°F. Automotive clutch hubs similar to the one in Fig. 8 were being quenched by a conventional quenching method. Each

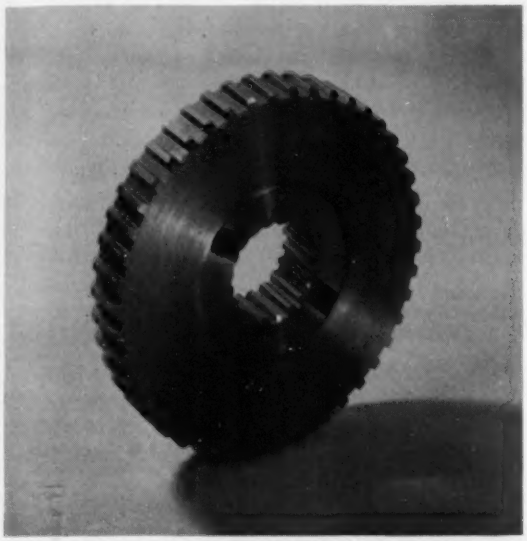


Fig. 8—Automotive clutch hub (SAE 1146 steel) that has been carbonitrided to a case depth of .005" at 1500°F.; hot oil quenched at 350°F. for 6-10 minutes; air cooled; tempered at 375°F.; and achieves a Rockwell "C" hardness of 60.

clutch hub, SAE 1146 steel, was carbonitrided to a case depth of .005" in a batch type furnace at 1500°F. Subsequently, the part was quenched in mineral oil at 130°F. and then tempered at 375°F., to a hardness of 30 Rockwell "C". Because of excessive grain growth of each clutch hub (internal bore tapered in more than the allowable .001" and the O.D. changed more than .002") each part required considerable machining after quenching. The internal teeth had to be honed and the external teeth ground. This resulted in very expensive machining operations with decreased production and quality of finished piece.

Hot oil quenching was tried as a means of expediting the operation and improving the qualities of the finished pieces. Parts were quenched in oil at 350°F. for a period of 6 to 10 minutes and then allowed to air-cool for approximately one and one-half hours. After tempering at 375°F. a Rockwell "C" hardness of 60 was obtained. Additional desirable attributes resulting from the employment of the hot oil quenching technique were:

1. Greater dimensional stability. Internal bore changed less than .0005" and O.D. less than .001".
2. The parts can now be machined "green" or before heat treatment. This operational change permits considerable savings because of the relative ease of machining green stock.
3. Further savings resulted through longer tool life and increased production.
4. Much higher hardness of finished material was obtained with a surface Rockwell "C" of 60 and a core Rockwell "C" of 48.

Fig. 9 illustrates some of the problems encountered during the conventional quenching of roller bearings and how the difficulties were eliminated by the hot oil quenching process.

Previously, large roller bearings of A.I.S.I. 52100 steel tended to crack at the flange when quenched in oil at 130°F. By using a marquenching oil at 375°F., the problem was completely eliminated.

Retainer rings, center piece of Fig. 9, tended to warp when quenched in oil at 130°F. Complete dimensional stability was obtained when similar parts were quenched at 375°F.

Small bearings of A.I.S.I. 52100 steel cracked when quenched in oil at 130°F. This problem was also eliminated in 375°F. oil.

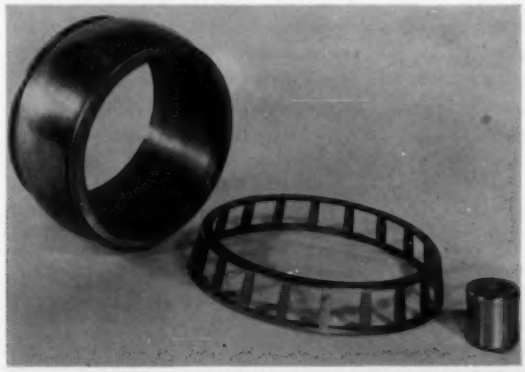


Fig. 9—A.I.S.I. 52100 steel roller bearings and races and SAE 1010 steel retainer rings no longer crack nor warp if hot oil quench is used.

The following example is presented to show how steel requirements can be downgraded by a modified marquenching process using a premium quenching oil with an accelerated quenching rate. Fig. 10 shows a typical machinery component produced from SAE 1024 steel. Due to the high cost of using SAE 8620 steel for these parts a decision was made to downgrade to SAE 1024 plain carbon steel. Because it was necessary to satisfy three critical requirements of torque strength, minimum 60 Rockwell "C" surface hardness, and maximum straightness, several quenching oils

Fig. 10—SAE 1024 steel shafts of an automotive part were able to be used instead of SAE 8620 steel because of hot oil quenching.

were tested to determine whether the substitution of 1024 steel would be permissible. The results are listed below:

1. Only a modified marquenching oil with an accelerated quenching rate was effective.
2. An oil bath temperature of 300°F. gave optimum results.
3. Shaft straightness was held to a maximum.
4. Rockwell "C" 62-64 was obtained on the SAE 1024 carburized steel.
5. High core hardness and torsion tests revealed that the maximum torque strength was obtained.

### *Oil Requirements*

The broad acceptance of hot oil quenchants by industry is evidence that these oils have been vastly improved in the last decade. Special refining processes which include dewaxing, de-asphalting and solvent extraction, plus the elimination of volatile components have produced exceptionally high quality products ideally suited to the hot oil quenching process. Moreover, modern heat treating facilities have also made it possible to use oil up to 450°F. with continuous service for a minimum of 15,000 hours before oil change-over is required.

In selecting an oil, the following physical properties are cited as typical tests of premium products:

| *Tests* | *Full Marquencing Oil* | *Modified Marquencing Oil* |
|---|---|---|
| Flash, °F. Min. | 525 | 410 |
| Fire, °F. Min. | 595 | 470 |
| Viscosity @ 100°F. Sus. | ..... | 235-275 |
| Viscosity @ 210°F. Sus. | 118-122 | 50-51 |
| Viscosity @ 300°F. Sus. | 51-52 | 36.5-37.5 |
| Viscosity @ 350°F. Sus. | 42-43 | ..... |
| Viscosity @ 400°F. Sus. | 38-39 | ..... |
| Viscosity @ 450°F. Sus. | 35-36 | ..... |
| Viscosity index, Min. | 95 | 100 |
| Acid Number | 0.00 | 0.00 |
| Fatty Oil | None | None |
| Carbon Residue | 0.45 | 0.05 |
| Color, NPA | 6+ | Light Green |

Particular attention should be given to the flash and fire points and viscosity because these physical properties help to govern the upper temperature limits of an oil. A high viscosity index (95 Min.) is indicative of a highly refined base stock having good oxidation stability at elevated temperatures. The absence of acid number is another indication of the high refinement typical of premium oils recommended for the hot oil quenching process. In general, the incorporation of additives in full marquenching oils is not recommended, since many tend to decompose at temperatures above 300°F. In the case of modified marquenching oils, special additives can be added since these products are limited to 300°F., oil bath temperature. Additions in this case are primarily employed to accelerate the quenching rate of the oil.

### *Used Oil Tests in Hot Oil Quenching*

An important consideration in the utilization of quenching oil is the significance of used oil tests. It is recommended that a sample of used quenching oil be checked periodically to determine its suitability for continued service. To properly analyze the results, it is necessary to understand the meaning of the following recommended tests:

1. Flash and fire points: these tests are recommended to safeguard against possible contamination with water or dilution with volatile fluids which would create a fire hazard.
2. Viscosity: an increase in viscosity of the used oil as compared with new oil indicates the extent of oil oxidation, polymerization and thermal cracking.
3. Acid number: an increase in acid number indicates the degree of formation of oxidation products. This test, in conjunction with a viscosity determination, is often an indication for subsequent sludge formation.
4. Sludge content: the degree of sludge formed from oxidation and contamination should be determined.
5. Hardness test: if hardness value of the workpiece decreases, the oil should be examined. A drop in hardness results may indicate that the oil has undergone significant change. Change in hardness, of course, also may be a result of bath temperature variations or other heat treat-

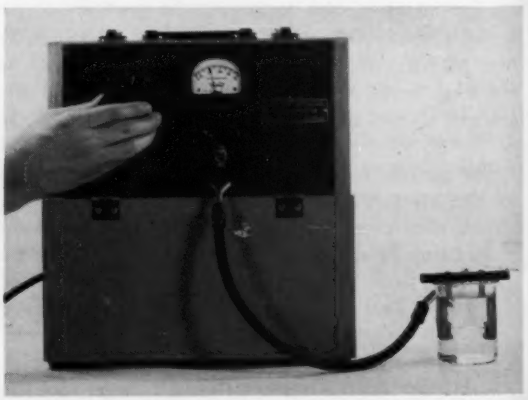


**Fig. 11—A Quenchol demonstrator for use in periodically determining the quenching power of the oil.**

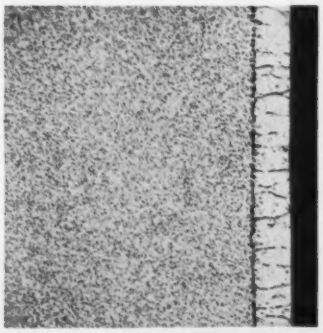
*(Continued on page 59)*

# How Chemical Coatings Protect Steel from Decarburization, Carburization, Scaling, or Nitriding

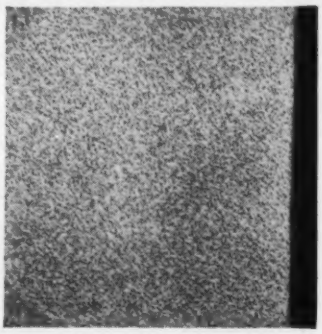
When steel is heated, it is often desirable to protect the surface from decarburization, carburization, scaling or nitriding. This is now possible with chemical coatings that are easily applied by dipping, brushing, or spraying. These protective coatings are suitable for selective carburizing or selective nitriding and also prevent decarburization or scaling.

## For Prevention of Carburization or Decarburization

No-Carb prevents undesired carburization or decarburization when properly applied to clean and dry steel surfaces. It is used for selective carburization in solid or gas carburizing and for the prevention of decarburization on high alloy steels during heating for rolling, forging, and hardening. No-Carb is especially suitable for protecting the surfaces of high speed steel tools hardened from furnaces with or without atmospheric control. It is not designed for use in salt baths or on threaded areas.



*Unprotected edge of high speed steel showing decarburization after hardening.*



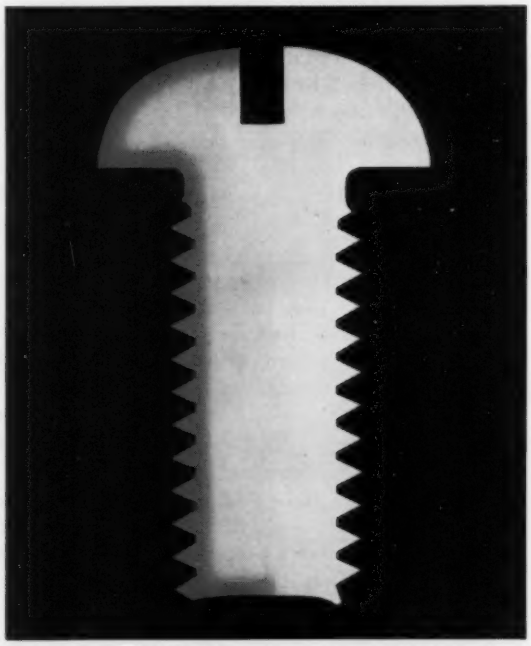
*No-Carb protected edge of hardened high-speed steel. Note lack of decarburization.*

## For Selective Carburization in Liquid Baths and Solid Carburizers

No-Kase furnishes positive protection against carburization in pack carburizing compounds and in certain liquid carburizing salts. It also performs satisfactorily in some gas atmospheres. No-Kase is particularly advantageous where such difficult sections as threads are to be protected against carburization. In liquid carburizing, No-Kase is most effective in a barium energized salt bath composed of Park-Kase No. 1-S and replenished by Park-Kase No. 1 or No. 2 Energizer.

## For the Prevention of Excessive Scaling on Steel

Here, Park No-Scale can be used effectively to prevent the formation of excessive scale on high alloy steels, die blocks and forgings. It acts as a die lubricant and prevents the loss of valuable alloys during heating operations. No-Scale is also used on the outside of steel pots to prevent excessive oxidation.



*Example of selective carburization with Park No-Kase. Note clear cut line of demarcation between the protected and unprotected areas.*

## Carbon Preventive

Carbon Preventer is a plastic compound for the prevention of carbon penetration into steel. It is used on threaded sections and other locations where the removal of No-Carb might be difficult. It is not designed for use in salt baths. For further information or an analysis of your specific problem, write to PARK CHEMICAL COMPANY, 8074 Military Avenue, Detroit 4, Mich.

## NEWS TO HEAT TREATERS

(*Continued from page 45*)

### IHEA ANNUAL MEETING

Walter Holcroft, Executive Vice President of the Holcroft Company, Detroit, Michigan, was elected President of the Industrial Heating Equipment Association at its recent annual meeting in Washington, attended by 75 top industry executives.

C. Floyd Olmstead, President of the Lee Wilson Engineering Company, Cleveland, Ohio, was named Vice President; Carl L. Ipsen was re-elected Executive Vice President; and Ralph E. Whittaker, Secretary of Swindell-Dressler Corporation, Pittsburgh, Pennsylvania, is again serving as Treasurer.

New members of the Board of Directors include: A. E. Tarr, Leeds and Northrup Company, Philadelphia, Pennsylvania; A. R. Robertson, Wayne Industrial Furnace Company, Detroit, Michigan; and R. L. Harper, Harper Electric Furnace Corporation, Buffalo, New York.

E. E. Staples of Hevi Duty Electric Company, Milwaukee, Wisconsin, past president of IHEA, in his Presidential Report to the members said that the "Association has continued its forward progress during the past year," with the Treasurer's Report showing an increase in the Association's net worth.

He noted that papers presented by the members in Cleveland at the Metal Congress were well received; that the publicity committee has prepared another series of papers for presentation at the Western Metal Congress in March; and that the Association will also participate in the Second World Metallurgical Congress to be held in Chicago, November 4 to 8 of this year.

In concluding, the past president stated: "We face the year ahead with confidence. . . . the sages . . . predict that '57 will be . . . better than our peak year of '56, which was 20% ahead of '55. Carl Ipsen has . . . reported that the business of Association Members showed a 265% increase in the three post-Korean war years over the three post-World War II years." He expressed confidence that this rising tide of fortune will continue.

Mr. Staples then referred to the new industrial revolution being wrought by enlightened management and intelligent workers. As an example he referred to an outstanding industrialist who admitted that every time he spent money in his company to improve working conditions, he made more profit because the workers became more careful, more cooperative and a better class of workers was attracted.

"The good will being built in working together is reflected," he concluded, "in customers' confidence. The better we serve our customers, the greater will be their desire for our products." We must apply "the highest moral and spiritual principles to our daily business lives" to achieve the fullest satisfaction.

### TRANSLATIONS AVAILABLE

Aware that much good literature of value and interest to heat treaters is being published abroad, METAL TREATING has made arrangements with a professional translator to advise us regularly of the availability of English translations of outstanding magazine articles, books, texts, etc., that would be of value to heat treaters.

The following translations are available from Henry Brutcher, P. O. Box 157, Altadena, California; all are illustrated and all have bibliographies. They may be secured by ordering directly from Mr. Brutcher.

No. 3787—*Influence of Alloying Elements on the Case Hardenability of Carburizing Steels;* by H. U. Meyer, translated from *Stahl Und Eisen,* Vol. 76, 1956 ($6.40)

No. 2829—*Two New Processes of Case Hardening and Prestraining of Steel by Carbonitriding;* by J. Pomey, F. Goutel, A. Veragen, and R. Le Roux, translated from *Comptes Rendus* (Paris), Vol. 231, 1950 ($2.50)

No. 1514—*The Use of Paint Instead of Copper Plating in Selective Carburizing;* by V. Petrov, translated from *Aviatsionnaya Promyshlennost,* Vol. 1, 1941 ($1.00)

No. 1579—*The Laws of Diffusion as Applied to the Carburizing of Steel;* by A. Slattenscheck, translated from *Hartereitechnische Mitteilungen,* Vol. 1, 1942 ($3.25)

No. 1489—*Causes and Characteristics of Fatigue Failures in Steels of High Hardness;* by M. Muzzoli, translated from *Metallurgia Italiana,* Vol. 33, 1941 ($1.95)

No. 2862—*Isothermal Transformation of Austenite in the Pearlite Range from the Carburizing Temperature;* by H. M. Meingast, translated from *Durferrit Hausmitteilungen,* 1952 ($2.75)

No. 1139—*Flaking of Steel Caused by Hydrogen Absorbed During Processing* (Such as *Carburizing*); by E. Houdremont and H. Schrader, translated from *Stahl und Eisen,* Vol. 61, 1941 ($4.95)

No. 1176—*Determination of Depth of Case of Tractor Treads by Magnetic Method;* by M. Braun and B. Sobolev, translated from *Zavodskaya Laboratoriya,* Vol. 10, 1941 ($1.20)

No. 3500—*Effect of Cyclic Stressing Upon Diffusion in Plain Carbon Steels;* by H. Schenck and E. Schmidtmann, translated from *Archiv Eisenhuttenwesen,* Vol. 25, 1954 ($4.85)

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## HOT OIL QUENCHING

*(Continued from page 56)*

ing deviations, change of steel composition, etc.

6. Appearance of workpiece: quenched parts which show a brownish varnish and laquer deposit may indicate that the oil has undergone significant change caused by length of service, contamination, etc.
7. Cooling power: by means of the Quenchol demonstrator as seen in Fig. 11, a quick check can be made periodically to determine the quenching power of the oil. The Quenchol demonstrator includes an electrical resistance wire which is immersed in a sample of quenching oil heated to the desired temperature. An electric current is supplied through the wire at an increasing rate which causes the wire to gradually develop more heat. As the heat in the wire increases, the quenching oil is required to transfer a larger amount of heat away from the wire or cool it at a faster rate. Eventually the heat is not transferred from the wire rapidly enough, and the wire melts and breaks the circuit. At this moment the amount of current required to melt the wire is observed on the ammeter. Through mathematical conversion a formula for the relative cooling power value has been calculated, and in simple terms represents the square of the current ($I^2$ Max.) necessary to melt the wire. By this test method cooling power values of quenching oils can be determined readily. ■■■

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## RIGHT OR WRONG IN LABOR RELATIONS

*(Continued from page 24)*

***What Arbitrator Lewis Gill Ruled:***

"Though Jaeger may have honestly felt that Dore had treated him unfairly in refusing permission to leave, and although he had made sure that the men under him were properly instructed on the work to be done before quitting time, he knew it was a violation of the rules to walk out after permission had been denied. He obviously should have made some attempt to persuade Dore of the urgency of his mission, or taken up the problem with his steward or higher management. There *are* extenuating circumstances. Dore's refusal of a pass seems to have been a bit arbitrary; it appears that the general practice *has* been for the foreman to grant requests under such circumstances, or at least check with higher management if the request seems inopportune. All this strongly suggests that the situation should have been handled differently both by Dore *and* by Jaeger. The fact remains that Jaeger was guilty of improper conduct. My conclusion is that the suspension should be sustained and the grievance dismissed." ■■■


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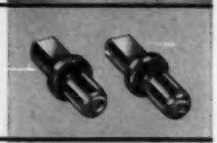

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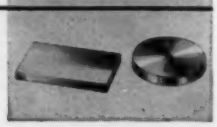

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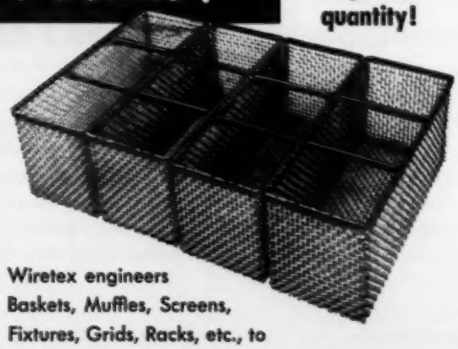

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## VACUUM MELTING

(*Continued from page* 16)

pumped hot retort furnace is used. In this case, a high vacuum is maintained inside the retort and the so-called rough vacuum is held between the furnace retort and the furnace shell proper (Fig. 6). The vacuum maintained on the brickwork cannot be as fine as the one that would be maintained within a clean chamber and this accounts for the two separate pumping systems.

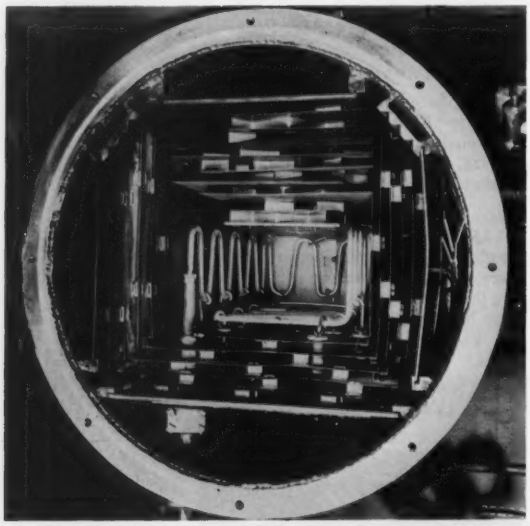

**Fig. 7—Inside view of a small "Kold-Retort" vacuum furnace showing the heating elements and the radiation shields.**

If we compare heat transfer in air and vacuum, we will find that when heating something in air, the heat is transferred both by radiation and by convection of the air. On the other hand, in vacuum, the heat transfer can be by radiation only. Transfer by radiation is essentially the same method of transfer as for light, and we know that if we interpose mirrors in the path of light, the light will be reflected. This philosophy can be applied in vacuum furnace design where radiation shields are interposed between the heat source and the vacuum retort, and in this fashion these shields can act as reflectors and replace the bricking completely. A fan can be put in this type furnace. The purpose of the fan is not to bat the remaining gas molecules around the vacuum, but that it is used only during cooling. In order to speed up the cooling in such a furnace, an inert gas such as argon or helium is introduced into the furnace and the fan recirculates that gas between the outer radiation shield and the water-cooled shell and back over the work to provide the fastest cooling method possible in a vacuum furnace.

A large furnace using the same construction principle has now been built and can handle a charge of up to 10,000 pounds of titanium. Considering that the price of the finished product is close to $20 a pound, this means that a single load will have a value of $200,000 which is more than the value of the complete furnace installation. Figs. 7 and 8 show an inside view of a small and large "Kold-Retort" Furnace.

### *Vacuum Heat Treating*

The basic applications of a vacuum heat treating furnace are essentially degassing, annealing, brazing, and sintering. In a degassing furnace which could be any of the furnaces described, the material is heated and at high temperature and under vacuum any undesirable gasses present in it will evolve. In the annealing treatment, the material is heated in order to soften it. This annealing is done under vacuum since vacuum will keep the part brighter than a protective atmosphere. Quite frequently, mainly with titanium, the process of degassing and annealing is combined into a single heat treating operation.

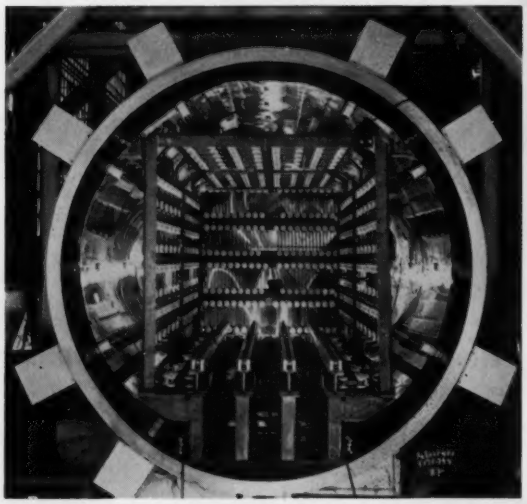

**Fig. 8—Inside view of a large "Kold-Retort" vacuum furnace. The radiation shields are located along the inside edge of the retort.**

It has been determined by the Government on aircraft work that brazing conducted under vacuum would yield much more satisfactory products than the one conducted in a protective atmosphere. To date, no explanation has been found for that phenomenon, but the results are beginning to be applied more and more to industrial production. The main reason for sintering under vacuum is the fact that the organic binder used in the powder to be sintered can be removed by the vacuum while at the same time the vacuum provides an adequate protection to the parts.

If we now measure the rapid growth of the vacuum metallurgy industry in the past five years and extend this in the future we can see that very soon vacuum melted and processed metals are going to take a more and more important place in America. ■■■

# Tool Steel Topics

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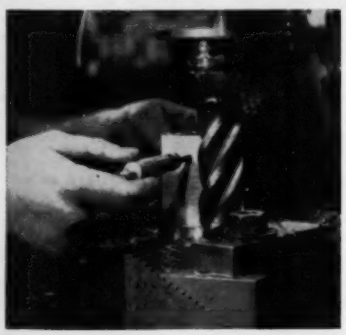
## Maker of Parts for TV Sets Gets Good Results with BTR

Here's a job where BTR (Bethlehem Tool Room) tool steel gets a good chance to show what it can do. The multiple-purpose die is used by Suckle Electronics Company, Camden, N. J., to pierce, notch, louver and form high-voltage shields for TV sets. The shields are made of 16-gage steel, and are turned out in a 95-ton press at the rate of more than 400 pieces per hour.

Engineers at Suckle Electronics report that they are well satisfied with BTR. They particularly like its safe-hardening property, toughness, and ability to wear and wear.

BTR is our general-purpose, manganese-chromium-tungsten grade of oil-hardening tool steel. It's a grade that is consistently racking up substantial shop savings for manufacturers in a wide range of applications. Your Bethlehem tool-steel distributor will be more than pleased to furnish complete information about BTR. Why not give him a phone call right now, while you have it in mind!



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## CR-MO-W Gets the Okay

After being machined by the end mill, this hot-piercing punch, made of Bethlehem Cr-Mo-W (chrome-moly-tungsten) tool steel, gets final size check by micrometer. Cr-Mo-W, an excellent hot-work steel, contains 5 pct chromium. Because of its characteristics, it is perfectly at home on jobs that involve shock, drastic changes of temperature, and heat-checking.

## BETHLEHEM TOOL STEEL ENGINEER SAYS:

*Don't Double Everything!*

Attempting to double everything may be a wise policy in the investment field. But it can cause trouble when applied to the selection of tool steels. For example, when a successful production line is to be duplicated in larger size, the same grade of steel should not be used for each part without further consideration.

The main difficulty which arises is that the steel for a given part may not have sufficient hardenability when the part is to be made in a larger size. The reason is that tools which have been only partially hardened through will not be as strong as the deeper hardened or through-hardened tools of the original model. Secondly, the use of low-hardenability steels may be troublesome because the larger tools may be under-tempered in attempting to develop the desired degree of surface hardness. You may find that tools which are improperly tempered sometimes crack in treatment, grinding, or in service. Steel for each tool must therefore be selected with reference to the size in which the tool is to be produced.

(Continued from page 58)

***Editor's Note:*** *The Industrial Heating Equipment Association after consultation with representatives of companies purchasing to Joint Industry Conference standards decided to try to fill the gaps insofar as industrial heating equipment is concerned by preparing these interpretations. They have no official standing and have not been approved or adopted by J.I.C.*

## RECOMMENDED INTERPRETATIONS OF J.I.C. ELECTRICAL STANDARDS AS APPLIED TO INDUSTRIAL HEATING EQUIPMENT

| J.I.C. Reference Paragraph | Processing furnaces, ovens, atmosphere generators, induction and dielectric heating equipment which are quoted or purchased to J.I.C. Specifications will conform to J.I.C. Standards for Industrial Equipment with the following interpretations. These interpretations have been adopted by the Industrial Heating Equipment Association, Inc. as recommended practice. |
|---|---|
| EO | General Exceptions to the J.I.C. Standards, these interpretations, or additional local requirements, shall be stated. |
| E 1.2.2<br>E 1.2.3<br>E 1.3.1 | **Diagrams:**<br>Installation, interconnection and elementary diagrams as well as electrical stock lists and sequence of operation will, when practicable be shown on one sheet. If more than one sheet is used they will be cross referenced and no sheet will be larger than 36" x 48". A sheet metal pocket in one of the enclosures will be provided for holding a complete set of diagrams. |
| | **Enclosures and Disconnects:** |
| E 2.5.4 | Motor controls will be mounted in one or more NEMA 12 enclosures each provided with a disconnect switch or breaker. |
| E 2.5.4 | Magnetic contactors for power supplies to electric heaters other than induction and dielectric equipment will be mounted in one or more NEMA 12 enclosures each provided with a disconnect switch or breaker. |
| E 2.2.2 | The switch or breaker will disconnect all power from the devices in the enclosure and associated equipment, be an integral part of the enclosure, be mechanically or electrically interlocked with the enclosure door and arranged so that it may be locked in the OFF position. |
| E 2.2.2<br>E 2.2.2 (F) | Where removal of all power would result in damage to the heating equipment or create hazardous operating conditions the associated control devices and circuits will not be deenergized by the switch on the NEMA 12 enclosure or an emergency bypass switch will be furnished. A conspicuous warning plate will be mounted adjacent to the controls and circuits which are not deenergized when the disconnect switch is OFF. |
| E 2.5.4 | Induction heating and dielectric equipment and frequency converters used with such equipment are not considered control panels and will not be mounted in NEMA 12 enclosures. The doors of all enclosures on |
| E 2.2.2 | induction heating equipment may not be mechanically interlocked. Interlocks will be provided on every enclosure door which given access to power circuits within such enclosure. The potential portion of the high frequency metering circuit of MG Induction heating equipment may be energized from the incoming side of the high frequency power contactor. This circuit will be fused and so protected by physical location that personal contact will be very difficult. |
| E 2.2.1 | A main disconnect switch for an entire equipment will not be furnished unless specified by the purchaser. |
| E 2.5.4 | Enclosures for electronic and other heat generating equipment will be ventilated when necessary.<br>Flowmeters or pumps for flammable fluids or gases will not be mounted on or in enclosures having arcing electrical contacts within. |
| | **Wiring:** |
| E 4.1.4 | All external wiring 60 cycles or less will be of sufficient size to permit one size larger motor to be used or 20% more current for heating power to be carried. Motor and control wiring external to enclosures will be enclosed in rigid conduit, liquid tight flexible conduit or oil, moisture and dustproof raceways. |
| E 4.1.6<br>E 4.2.1 | If ambient temperatures are expected to exceed 80 C type AVA or equivalent insulation will be used on motor and control wiring. Terminations will be made with crimp type, pressure type or brazed connectors. |
| E 4.2 | Leadwire for temperature measuring primary elements will be of standard manufacture. |
| E 4.1.6<br>E 4.2<br>E 4.6 | Heating conductors will be bus bar or type AVA or equivalent stranded cable. Runs may be on protected open supports, in rigid conduit or enclosed raceways. Cable terminations will be crimp or pressure type or brazed or welded connectors on furnace terminals protected with guards which may be ventilated. |
| E 4.6.4 | For circuits to devices requiring frequent movements, extra flexible single or multiconductor cable will be used. |
| E 1.7.1<br>E 1.9.1 | Where purchaser must install external wiring to the heating equipment the vendor will recommend the number of wires required between components and the ratings of the connected loads, but is not required to specify the size or number of conduits. |
| E 2.7.5 | Enclosed control panels will be front wired when practicable. Line voltage devices will be separated from control voltage devices wherever possible within a panel. Control |
| E 2.6.9<br>E 2.5.4 (F) | voltage (115 volts AC) wiring shall be separated from higher voltage lines or 250 volt DC control voltage lines. Temperature, flow, pressure, etc. instruments may be mounted on open panels. |
| | **Motors:** |
| E 2.1.2<br>E 2.3.1<br>E 2.4.1 | All motors of 1/4 H.P. or larger will be totally enclosed, polyphase and controlled by magnetic starters of NEMA size 1 or larger. Gear head, brake, flange mounted or hollow shaft motors may be used. All motors |
| E 3.2.3 | will have overload protection by over-current devices or by inherent motor characteristics and will be individually or group fused according to requirements of the National Electrical Code. |
| E 2.3.1 | Motors smaller than 1/4 H.P. used to operate auxiliary devices such as small blowers, small pumps, time switches, timers, etc., may be operated directly from the control circuit without individual overload protection. |
| E 2.6.2 | The two-foot limitation is not always possible relative to induction heating equipment but shall apply wherever practicable. |

# METAL TREATING

# EQUIPMENT and MATERIALS DIRECTORY

## CHILLING MACHINES

CINCINNATI SUB-ZERO PRODUCTS COMPANY
3932 Reading Road
Cincinnati, Ohio

★ ★ ★

## CLEANING EQUIPMENT

PANGBORN CORPORATION
Hagerstown, Maryland
WHEELABRATOR CORPORATION
Mishawaka, Indiana

★ ★ ★

## FABRICATION
### (Heat & Corrosion Resistant)

GENERAL ALLOYS COMPANY
367-405 West First Street
Boston 27, Massachusetts
THE PRESSED STEEL COMPANY
Wilkes-Barre, Pennsylvania
ROLOCK, INC.
1232 Kings Highway
Fairfield, Connecticut
WIRETEX MFG. CO., INC.
16 Mason Street
Bridgeport 5, Connecticut

★ ★ ★

## FIXTURES

GENERAL ALLOYS COMPANY
367-405 West First Street
Boston 27, Massachusetts
INTERNATIONAL NICKEL CO., INC.
67 Wall Street
New York 5, New York
MISCO FABRICATORS, INC.
1999 Gusin Street
Detroit 7, Michigan
THE PRESSED STEEL COMPANY
Wilkes-Barre, Pennsylvania
ROLOCK INC.
1232 Kings Highway
Fairfield, Connecticut
STANWOOD CORP.
4825 West Cortland Street
Chicago 39, Illinois
WIRETEX MFG. CO., INC.
16 Mason Street
Bridgeport 5, Connecticut

★ ★ ★

## FLAME HARDENING

OHIO CRANKSHAFT COMPANY
4620 East Seventy-first
Cleveland, Ohio

★ ★ ★

## FLOW MEASUREMENT

SELAS CORPORATION OF AMERICA
Dresher, Pennsylvania

★ ★ ★

## FURNACES

AMERICAN GAS FURNACE CO.
808 Lafayette Street
Elizabeth, New Jersey
DENVER FIRE CLAY COMPANY
2301 Blake Street
Denver, Colorado
DOW FURNACE COMPANY
12045 Woodbine Avenue
Detroit 28, Michigan
ECLIPSE FUEL ENGINEERING CO.
1018 Buchanan Street
Rockford, Illinois
HEVI DUTY ELECTRIC COMPANY
Milwaukee 1, Wisconsin
HOLCROFT AND COMPANY
6545 Epworth Boulevard
Detroit 10, Michigan
INDUSTRIAL HEATING EQUIPMENT CO.
3570 Fremont Place
Detroit 7, Michigan
JOHNSON GAS APPLIANCE COMPANY
522 East Avenue
Cedar Rapids, Iowa
LINDBERG ENGINEERING COMPANY
2466 West Hubbard Street
Chicago 12, Illinois
SELAS CORPORATION OF AMERICA
Dresher, Pennsylvania
THE SENTRY COMPANY
Foxboro, Massachusetts
SURFACE COMBUSTION CORPORATION
HEAT TREAT DIVISION
Toledo, Ohio
YOUNG BROTHERS COMPANY
1849 Columbus Road
Cleveland 13, Ohio

★ ★ ★

## FURNACES (Salt Bath)

AJAX ELECTRIC COMPANY
940 Frankford Avenue
Philadelphia 23, Pennsylvania
THE A. F. HOLDEN COMPANY
14341 Schaefer Highway
Detroit 27, Michigan

★ ★ ★

## GAS GENERATORS

HEVI DUTY ELECTRIC COMPANY
Milwaukee, Wisconsin
HOLCROFT AND COMPANY
6545 Epworth Boulevard
Detroit 10, Michigan
LINDBERG ENGINEERING CO.
2466 West Hubbard Street
Chicago 12, Illinois
SURFACE COMBUSTION CORPORATION
HEAT TREAT DIVISION
Toledo, Ohio

★ ★ ★

## GASES

ALLIED CHEMICAL AND DYE CORP.
NITROGEN DIVISION
40 Rector Street
New York 6, New York
ARMOUR AND COMPANY
AMMONIA DIVISION
1355 West 31st Street
Chicago, Illinois
HAMLER INDUSTRIES, INC.
6025 West 66th Street
Chicago 38, Illinois

★ ★ ★

## HEATING ELEMENTS
### (Non-Metallic)

NORTON COMPANY
Worcester 6, Massachusetts

★ ★ ★

## INDUCTION BRAZING

OHIO CRANKSHAFT COMPANY
4620 East Seventy-first
Cleveland, Ohio

★ ★ ★

## METAL FINISHING

ARTHUR TICKLE ENGINEERING WORKS, INC.
23 Delevan Street
Brooklyn, New York

★ ★ ★

## NITRIDING

UNITED STATES STEEL CORP.
OIL WELL SUPPLY DIVISION
Oil City, Pennsylvania

## QUENCHING OILS

E. F. HOUGHTON & CO.
303 West Lehigh Avenue
Philadelphia 33, Pennsylvania
PARK CHEMICAL COMPANY
8076 Military Avenue
Detroit 4, Michigan
SHELL OIL COMPANY
50 West 50th Street
New York 20, New York
SINCLAIR REFINING COMPANY
600 Fifth Avenue
New York, New York
SUN OIL COMPANY
Industrial Products Department
Philadelphia 3, Pennsylvania

★ ★ ★

## REFRACTORIES

DENVER FIRE CLAY COMPANY
2301 Blake Street
Denver, Colorado
NORTON COMPANY
Worcester 6, Massachusetts

★ ★ ★

## SALTS

ALLIED CHEMICAL AND DYE CORP.
NITROGEN DIVISION
40 Rector Street
New York 6, New York
AMERICAN CYANAMID COMPANY
METAL CHEMICALS SECTION
30 Rockefeller Plaza
New York 20, New York
THE A. F. HOLDEN CO.
14341 Schaefer Highway
Detroit 27, Michigan
E. F. HOUGHTON & CO.
303 West Lehigh Avenue
Philadelphia 33, Pennsylvania
PARK CHEMICAL COMPANY
8076 Military Avenue
Detroit 4, Michigan

★ ★ ★

## STRAIGHTENING EQUIPMENT

GENERAL MANUFACTURING COMPANY
6437 Farnsworth
Detroit 11, Michigan

★ ★ ★

## SUB-ZERO TREATMENT

CINCINNATI SUB-ZERO PRODUCTS CO.
3932 Reading Road
Cincinnati, Ohio

★ ★ ★

## TEMPERATURE CONTROLS

METAL & THERMIT CORP.
100 Park Ave.
New York 17, New York
CLARK INSTRUMENT, INC.
10203 Ford Road
Dearborn, Michigan

★ ★ ★

## TESTING EQUIPMENT

STEEL CITY TESTING MACHINES, INC.
8817 Lyndon Avenue
Detroit 38, Michigan

★ ★ ★

## TOOL STEELS

BETHLEHEM STEEL COMPANY
Bethlehem, Pennsylvania
THE CARPENTER STEEL COMPANY
Reading, Pennsylvania
CRUCIBLE STEEL COMPANY OF AMERICA
Pittsburgh, Pennsylvania

## WATCH YOUR STEP

Postmasters at their Detroit convention viewed a talking stamp machine. You put in your coin, receive your stamps and the machine says: "Now buy some more and save a trip." And as you walk off, it calls: "Thank you, these stamps are sanitary."

A shirt company is marketing a new pair of men's shorts. They are resplendent with a red left leg, a green right leg and a white seat—and are called "port and starboard."

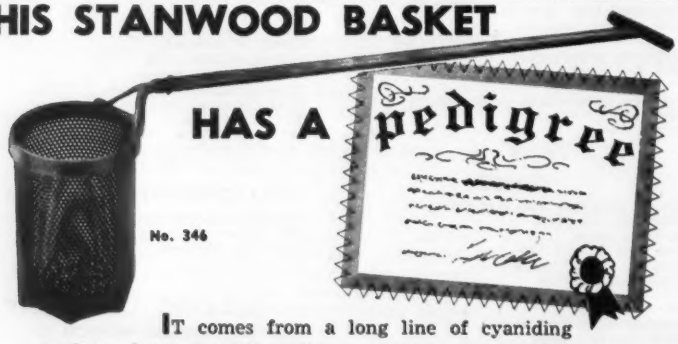
There's a new tooth paste that comes in your favorite choice of bourbon, scotch and rye flavors.

In Canada there's an insurance company that will sell auto insurance only to teetotalers.

What's it all add up to? Well, one thing at least. If you're caught in a pair of those multi-colored shorts talking back to a stamp machine with alcoholic tooth paste on your breath, you won't be able to buy any of that Canadian auto insurance.

*—The Milwaukee Journal*


# THIS STANWOOD BASKET




IT comes from a long line of cyaniding baskets that were blue ribbon winners, until today Stanwood's are the "best of the breed." Stanwood has just the basket to efficiently and economically handle your parts through heat treating—every design based on long experience and skilled fabrication methods—hundreds of designs. If we don't have it, Stanwood engineers will design a basket specially for you. Write for catalog.

*There's A Stanwood Representative Near You!*

Stanwood HEAT TREATING EQUIPMENT Corporation

4825 W. CORTLAND ST. CHICAGO 39, ILLINOIS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